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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G08G 1/0968	A1	(11) International Publication Number: WO 93/05492 (43) International Publication Date: 18 March 1993 (18.03.93)

(21) International Application Number: PCT/GR92/00016

(22) International Filing Date: 28 August 1992 (28.08.92)

(30) Priority data:
910100364 28 August 1991 (28.08.91) GR

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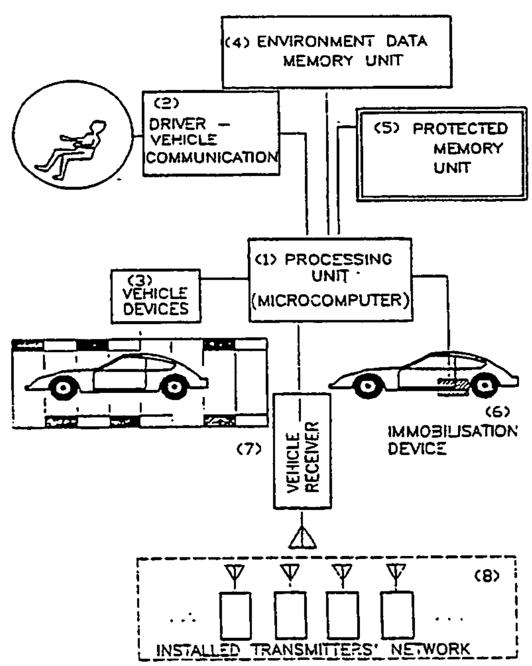
(81) Designated States: BG, BR, CA, CS, FI, HU, JP, KP, KR, NO, PL, RO, RU, SE, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, SE).

Published
With international search report.

(54) Title: METHOD FOR AUTOMATIC ROUTING, NAVIGATION, PROTECTION AND GUIDANCE FOR VEHICLE DRIVERS

(57) Abstract

The invention refers to a method of routing (that is setting-up the vehicle's course towards a predetermined destination), navigation (that is estimating and verifying the vehicle's position, on the road network at any instant and guiding the driver on the course and manœuvres he has to follow), protection (that is checking the vehicle's condition and driver's physical status, controlling the driving conditions and the proper performance of manœuvring and warning or interfering in case of emergency) and guidance (that is supplying information of any kind which fall into the driver's interest during driving), which method is characterised by the provision of a number of services to the driver in order to accommodate his/her needs during vehicle's movement (routing, navigation, protection and guidance services) using a limited number of devices and only by processing their indications, which devices are installed: 1) on-board the vehicle (measurement and protection devices); 2) on the driver (information devices); 3) on the surrounding area (guidance devices), and which devices are connected with and controlled by a data processing system which is installed on-board the vehicle, in such a way that the processing system, upon receipt of the devices' indications, based on pre-programmed criteria as well as on data stored in its memory unit, to identify the road network and the prevailing conditions in every spot (traffic signs, locations and buildings on both sides, topography etc.); estimate and verify the vehicle's position on the road network, at any instant; identify the vehicle's condition and driver's physical status; identify driver's immediate and future needs on protection and guidance, and based on these elements, it provides the driver with a number of services concerning the routing, navigation, protection and guidance requirements.



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METHOD FOR AUTOMATIC ROUTING, NAVIGATION, PROTECTION AND GUIDANCE FOR VEHICLE DRIVERS

A. INTRODUCTION

The invention refers to a method of routing (that is setting-up the vehicle's course towards a predetermined destination), navigation (that is estimating and verifying the vehicle's position, on the road network at any instant and guiding the driver on the course and manoeuvres he has to follow), protection (that is checking the vehicle's condition and driver's physical status, controlling the driving conditions and the proper performance of manoeuvring and warning or interfering in case of emergency) and guidance (that is supplying information of any kind which fall into the driver's interest during driving), which method is characterised by the provision of a number of services to the driver in order to accommodate his/her needs during vehicle's movement (routing, navigation, protection and guidance services) using a limited number of devices and only by processing their indications, which devices are installed:

1. On-board the vehicle (measurement and protection devices)
2. On the driver (information devices)
3. On the surrounding area (guidance devices)

and which devices are connected with and controlled by a data processing system which is installed on-board the vehicle, in such a way that the processing system, upon receipt of the devices' indiations, based on pre-programmed criteria as well as on data stored in its memory unit, to

* identify the road network and the prevailing conditions in every spot (traffic signs, locations and buildings on both sides, topography etc.)

* estimate and verify the vehicle's position on the road

network, at any instant

* identify the vehicle's condition and driver's physical status

* identify driver's immediate and future needs on protection and guidance

and based on these elements, it provides the driver with a number of services covcerning the routing, navigation, protection and guidance requirements.

B. STATE-OF-THE-ART

A list of all the known State-of-the-Art Patents, issued by the U.S. Patent Office is given hereinattached.

USA PAT.NR.	TITLE OF THE INVENTION	INVENTOR	COUNTRY	DATE OF PATENT ISSUE
4,023,017	ELECTRONIC TRAFFIC CONTROL SYSTEM	Ceseri (Autostrada SPA)	ITALY	10 MAY 1977
4,350,970	METHOD FOR TRAFFIC DETERMINATION A ROUTING & INFORMATION SYSTEM FOR INDIVIDUAL MOTOR VEHICLE DRIVE	Siemens	GERMANY	21 SEPTEMBER 1982
4,713,661	TRANSPORT.VEHICLE LOCATION MONITOR GENERATING UNIQUE AUDIBLE MESSAGES	Regency Elect-ronics Inc.	U.S.A..	15 DECEMBER 1987
4,633,517	CIRCUIT FOR DECODING TRAFFIC INFORMATION MESSAGE TONE SIGNALS	Deutsche ITT Industries	GERMANY	30 DECEMBER 1986
3,899,671	COMMUNICATION SYSTEMS	Harris Stover	U.S.A.	12 AUGUST 1975
4,408,179	COMMUNICATION SYSTEM FOR AUTOMOTI-VE VEHICLES	Nissan Motor Co.	JAPAN	04 OCTOBER 1983

USA PAT.NR.	TITLE OF THE INVENTION	INVENTOR	COUNTRY	DATE OF PATENT ISSUE
4,827,420	NAVIGATION APPARATUS FOR VEHICLE	Mitsubishi Denki	JAPAN	02 MAY 1984
4,849,827	DISK & NAVIGATION APPARATUS FOR POSITION LOCATING SYSTEM	Pioneer Electr. Corp.	JAPAN	18 JULY 1989
4,357,592	GUIDANCE SYSTEM FOR INDIVIDUAL TRAFFIC	Siemens	GERMANY	02 NOVEMBER 1982
4,951,211	ELECTRONIC GUIDING & INFORMATION SYSTEM FOR TRAFFIC	Gerard J.. De Villeroche	FRANCE	21 AUGUST 1990
4,679,147	NAVIGATION SYSTEM WITH CAPABILITY OF INSTRUCTING RUNNING DIRECTION	Hitachi Ltd.	JAPAN	07 JULY 1991
4,514,810	NAVIGATOR FOR VEHICLE	Nippondenso Co.	JAPAN	30 APRIL 1985

USA PAT.NR.	TITLE OF THE INVENTION	INVENTOR	COUNTRY	DATE OF PATENT ISSUE
Re.33,025	METHOD & APPARATUS FOR DISPLAY OF DISTANCE & DIRECTION OF DESTINATION	Nippon Soken Inc	JAPAN	15 AUGUST 1989
4,638,438	NAVIGATION APPARATUS FOR AUTOMOTIVE	Hitachi Ltd.	JAPAN	20 JANUARY 1987
4,774,671	NAVIG.SYSTEM FOR AUTOMOTIVE VEHICLE INCL.FEATURE OF UPDATING VEHICLE POSITION AT EVERY INTERSECTION ALONG PRESET COURSE	Nissan Motor Co.	JAPAN	27 SEPTEMBER 1988
4,646,089	TRAVEL GUIDANCE SYSTEM FOR VEHICLES	Nippondenso Co.	JAPAN	24 FEBRUARY 1987
4,758,959	VEHICLE NAVIGATION SYSTEM PROVIDED WITH AN ADAPTIVE INERTIAL NAVIGAT. SYSTEM, BASED ON THE MEASUREMENT OF THE SPEED & LATTERAL ACCELERATION OF THE VEH. & PROVIDED WITH A CORR. UNIT FOR CORRECTING MEASURED VALUES	Philips Co.	U.S.A.	19 JULY 1988

USA PAT.NR.	TITLE OF THE INVENTION	INVENTOR	COUNTRY	DATE OF PATENT ISSUE
4,792,907	VEHICLE NAVIGATION SYSTEM	Nippondenso Co.	JAPAN	20 DECEMBER 1988
4,796,210	METHOD FOR DISPLAYING THE SPEED AND DISTANCE ON BOARD A MOTOR VEHICLE	Veglia Co.	FRANCE	03 JANUARY 1989
4,782,447	SYSTEM AND METHOD FOR NAVIGATING A VEHICLE	Nissan Motor Co	JAPAN	01 NOVEMBER 1988
4,939,662	NAVIGATION APPARATUS	Aisin A W Co.	JAPAN	03 JULY 1990
4,937,753	ROUTE END NODE SERIES PREPARING SY-STEM OF NAVIGATION APPARATUS	Aisin A W Co.	JAPAN	26 JUNE 1990
4,787,040	DISPLAY SYSTEM FOR AUTOMOTIVE VEHICLE	International Business Machine	U.S.A.	22 NOVEMBER 1988
4,951,212	AUTOMOTIVE DRIVING GUIDE APPARATUS	Hitachi Ltd.	JAPAN	21 AUGUST 1990

USA PAT.NR.	TITLE OF THE INVENTION	INVENTOR	COUNTRY	DATE OF PATENT ISSUE
4,937,751	NAVIGATION APPARATUS	Aisin A W Co.	JAPAN	26 JUNE 1990
4,937,752	AN APPARATUS FOR CORRECTING DISTANCE ERROR IN A NAVIGATION SYSTEM	Aisin A W Co.	JAPAN	26 JUNE 1990
4,903,211	ON-BOARD NAVIGATION SYSTEM FOR MOTOR VEHICLES	Pioneer Electronic Co.	JAPAN	20 FEBRUARY 1990
4,907,159	DEVICE FOR RECEIVING & PROCESSING ROAD INFORMATION	Philips Co.	U.S.A.	06 MARCH 1990
4,943,925	NAVIGATION APPARATUS BASED ON PRESENT POSITION CALCULATING SYSTEM	Aisin A W Co.	JAPAN	24 JULY 1990
4,814,989	NAVIGATION METHOD FOR VEHICLES	Bosch GmbH	GERMANY	21 MARCH 1989
4,819,174	ROAD NAVIGATION SYSTEM	Mitsubishi Co.	JAPAN	04 APRIL 1989

USA PAT.NR.	TITLE OF THE INVENTION	INVENTOR	COUNTRY	DATE OF PATENT ISSUE
4,914,605	APPARATUS & METHOD FOR DISPLAYING A MAP	ETAK Inc.	U.S.A.	03 APRIL 1990
4,878,170	VEHICLE NAVIGATION SYSTEM	Eliahu I. Zeevi	U.S.A.	31 OCTOBER 1989
4,757,455	NAVIGATION SYSTEM FOR A VEHICLE	Nissan Motor Co.	JAPAN	12 JULY 1988
4,926,331	TRUCK OPERATION MONITORING SYSTEM	Navistar Int'l Transportation	U.S.A.	15 MAY 1990
4,939,652	TRIP RECORDER	Centrodyne Inc.	CANADA	03 JULY 1990
4,926,336	ROUTE SEARCHING SYSTEM OF NAVIGATION APPARATUS	Aisin A W Co.	JAPAN	15 MAY 1990
4,866,616	INFORMATION RECORDING APPARATUS FOR VEHICLES	Tokyo Keiki Co.	JAPAN	12 SEPTEMBER 1989

USA PAT.NR.	TITLE OF THE INVENTION	INVENTOR	COUNTRY	DATE OF PATENT ISSUE
4,858,133	DRIVE MANAGEMENT SYSTEM	Tokyo Keiki Co.	JAPAN	15 AUGUST 1989
4,546,434	METHOD & APPARATUS FOR DETERMINING ROUTE FROM A PRESENT LOCATION TO A DESIRED DESTINATION IN A CITY	Natividad Gene Esparza	SPAIN	08 OCTOBER 1985
4,371,934	VEHICLE TRIP COMPUTER	Bosch GmbH	GERMANY	01 FEBRUARY 1983
4,539,641	DATA PROCESSOR IN AUTOMOBILES	Hitachi Ltd.	JAPAN	03 SEPTEMBER 1985
4,564,905	TRIP COMPUTER FOR VEHICLES	Hitachi Ltd.	JAPAN	14 JANUARY 1986

C. GENERAL CHARACTERISTICS AND DISADVANTAGES OF OTHER INVENTIONS

The currently known systems for assisting the drivers, are limited to guidance and information of the driver. According to their function they are characterised as autonomous and dependent systems. The main function of the supporting systems, in general, is the determination of the real vehicle's position, at any instant:

1. In the autonomous systems, this function is accomplished by the summation (integration) of travelled distances from the starting point, which is measured by the odometer's indications in conjunction to the vehicle's turning angle (which is measured either by use of a gyroscopic compass or a magnetic compass or even by use of differential indications of wheels' rotation etc.). For eliminating possible errors, resulting from the erroneous odometer indication (e.g. due to wheels' slip) the vehicle's position is corrected when the change in its orientation is not in conformity with the expected mapping data, which are in the form of digital maps or data stored in magnetic disks or data in tapes.

2. In the dependent systems, the vehicle's position is verified by transmitters installed along the road network. The reception of a transmitter's position signal, from the guidance system, means that the vehicle is in the position where the transmitter is installed. In other dependent systems, the vehicle's position is verified by the processing of satellite signal.

Both systems, having the exact vehicle's location on the road network, may:

a. Give instructions to the driver, in general, concerning the course he/she has to follow in order to reach a predetermined destination. This is achieved by the vehicle's

computer's by reviewing the map, when the vehicle's position is given occasionally.

b. Give information of any nature (that is for locations or buildings at both sides of the road network, warnings for eventual traffic problems etc.). This is achieved by comparing the vehicle's position, occasionally, as soon as the on-board computer takes into consideration the encoded information externally received or the information stored in the memory unit, which information concerns the are where the vehicle moves in and the time of its movement. Upon completion of this main function of the systems, the information, warning, notification, protection and in general the driver's support is offered in various ways. The characteristics of these functions are the following:

(1) The main purpose of the systems is to make the contact between the vehicle's driver and the outer "environment" in which he/she is located or is moving to.

(2) The "environment" presented to the driver is, in most of the cases, a cartographical two-dimensional area representation, whilst the information offered concerns the condition of the environment at a certain moment.

(3) The elements taken into consideration, for the presentation of the data to the driver, are the vehicle's location and destination.

The disadvantages of these systems are the following:

1. During transmission of instructions or information, they do not take into consideration the general condition of the driver (that is the way of driving, the physical condition etc.), but only the vehicle's position and destination. Usually, they present on the screen, a map of the territory and they indicate the position and the destination of the vehicle. It is therefore often required that the driver

stops to orientate. The same applies on the transmission of information from the driver to the vehicle. Vehicle's stop and frequently keying-in of information is required.

2. The guidance and information offered by these systems do not address the needs of the driver for manoeuvring the particular vehicle. Therefore, the driver is not informed of hazardous road inclinations or hazardous road uneveness (e.g. at high speeds).

3. They do not provide to the driver instructions concerning necessary manoeuvres at a given instant. Usually the supplied instructions regard the direction the system user has to follow. The necessary manoeuvres, however, are left to be decided by the driver. Special instructions for the manoeuvring of the vehicle (e.g. for parking in a limited space, under specifications etc.) are completely missing in the common systems.

4. These systems lack the consideration of driver's physical status. Thus, the driver's reactions caused by bad physical status (that is reckless driving by intoxicated drivers, manoeuvres endangering other vehicles) are not taken into consideration by those systems.

5. A characteristic of those assisting systems is the fact that they do not refer to the particular vehicle on-board which they are installed. Practically, the instruction and information they offer, concern the vehicle's position and the destination and not the particular vehicle and its driver. Therefore, they cannot offer information or guidance addressed to a particular vehicle (e.g. IY 9060) or to a special-type vehicle (e.g. fire-fighting vehicle or truck), unless they are amended or extended.

6. The guidance and information in the existing systems, originates from a database usually stored in a high capacity memory unit (such as CD-ROM, DAT etc.). The elements of the

database are entered into the system's computer from a reading unit (e.g. disk drive).

A main disadvantage of these systems is the time elapsing from the data recording in the memory units till the use of the information by the driver (e.g. the change of the part of a road from two-way to one-way traffic takes time before it is recorded on a CD-ROM, for example, and then passed on to the user). Thus, there is always the possibility of having unreliable systems.

The above-mentioned disadvantages result from the fact that they are regarded mainly as information systems. For this reason, they use audio or visual ways for the transmission of information. In practice, however, during driving, the driver participates with a wider field of conception that covers both the surrounding area and the function and movement of the vehicle. For example, the driver deals only for a while with the direction he/she has to follow for the course from the position A to the position B. His/Her main concern is to adjust the vehicle's operations to the surrounding conditions, that is to watch the traffic signs and the other vehicles, to maintain the speed in normal levels, to change lane etc.

In view of the above, he/she does not only have special needs for information regarding the vehicle, but for a special way of transmission in order to cover the field of extended conception. Moreover, he/she needs guidance and information for special requirements deriving from the driving of a particular vehicle (e.g. instructions for parking a towed vehicle in a limited area). Finally, the driver needs to have control and protection when his/her phycical status or manoeuvres generate hazards.

A characteristic of these systems is that they mostly lack of driver's control services, concerning driving performance, and of drivers' protection, in case that a

certain hazard is likely to appear in a certain course.

Another basic element, to the disadvantage of these systems, is the fact that they do not provide any information or control over the environmental conditions (that is meteorological conditions, humidity, ice on the road surface), let alone adjust the instructions in order to induce the driver to take into consideration those environmental conditions during manoeuvring.

D. DISCLOSURE OF THE INVENTION

It concerns a method aiming at satisfying most of the needs of a driver during his/her circulation on the road network. The driver's needs are satisfied by a number of services offered by the method to the driver. These services are classified in groups of certain general categories according to the type of needs to be satisfied. Thus, the method offers:

1. Services for the vehicle's routing on the road network

By the term "routing" we signify the determination of a vehicle's course from a given origin towards a predetermined destination. With a view of providing the routing services, the method:

a. Takes into consideration the driver's requirements concerning the desired routing mode, that is short, economical, easy etc.
b. Takes into consideration the experience and the physical condition of the driver, which is automatically identified.
c. Takes into consideration the type and the geometry of the vehicle.
d. Takes into consideration the areas or buildings which are encountered or wished to be encountered by the driver during his/her travelling.

e. Takes into consideration the time or space constraints set-up by the driver for travelling along a certain route (specifications) and it automatically adjusts the selected route in order to meet those constraints.

f. Provides, from the start, the information about the selected route, such as its duration, its presentation on a part of the road map, its overall length, the number of required turns, the number of traffic lights included, etc.

g. Automatically selects, from the start, or adjusts certain selected route, taking into consideration the traffic congestion in one or more sections of the road network.

h. Automatically selects a new route towards the predefined destination if the vehicle deviates from its course, either on purpose or due to erroneous manoeuvring.

i. Selects routes towards multiple or successive destinations (each one after the other) with or without time constraints, in order to satisfy needs of professional or tourist nature.

j. Selects, at the driver's discretion, both the route and destination, if the latter belongs to a category of identical destinations (e.g. pharmacies, gas stations) and then it automatically selects the route that guides him/her faster to one of them.

k. Offers the service for arrival at a predetermined destination, at a certain moment, when it automatically selects, at the proper time, the route to guide him/her to the destination considering that the starting point is the vehicle's instantaneous position at the moment of the selection. During this service, the vehicle's course is monitored in order to avoid reaching its destination at a later time than the predetermined one.

l. Sets the course to unmapped areas off the road network, such as parking stations, docks, stadiums, jungles, deserts etc.

m. Sets the course for arrival at a predetermined destination, assisting professionals like taxi drivers, truck drivers etc., in fulfilling the needs of their

customers or their agency.

n. Sets the course from an origin to a predetermined destination in order to satisfy the needs of drivers who circulate on a road network interrupted by channels (where ferry boats are used) or in order to arrive at an island or to transit the customs etc., and it timely coordinates the vehicle's motion in order to be present at the appropriate time at the boarding point, at the check-point etc.

o. In order to set a course, it takes into consideration weather conditions (wind, ice, rain) which are monitored along the road network and which the method identifies and automatically compares with the peculiarities of the road network (declivities, hazardous slopes etc.) or it immediately amends the selected course in order to avoid such weather conditions.

The main feature of the routing services, as well as of most of the services provided by the method, is that they are provided automatically. By the term "automatically" we signify the activation of parameters or factors, either without the intervention of or with data input by the driver, and identification of data that influence or may influence the course to a certain destination and the amendment or the selection of a new route, so that these parameters or data do not impede but favour the carrying out of the course. Examples of the services' "automatic activation" feature are the following:

* If the driver drives for a long time e.g. 3 hours, the method automatically selects a comfortable route that does not lend more wear to the driver.

* If the vehicle deviates from its course, the method automatically identifies the deviation and sets a new course towards the destination. A different type of course e.g. fast for a small vehicle and a dissimilar one for a heavy-type truck, is automatically selected.

Another feature of the routing services is their "dynamic activation". The routing services are also activated without the driver's request, when the conditions demand so. Examples of dynamic activation, as mentioned before, are the deviations from a set course, in which case a new course originating from the deviation point is set.

Another example of dynamic activation concerns the service of regulating traffic. With this service, routing services are activated and courses for arriving at a destination in a dynamic interaction with other vehicles' courses, in order to avoid traffic congestion, are selected. In order to regulate the traffic, in some cases, the activation of routing services is effected from a distance (e.g. from the Traffic Police). Dynamic activation of the routing services is also effected in case of obstacles or adverse weather conditions, when a new course is selected for security reasons.

Another feature of the method is the fact that it requires a minimal number of devices installed on board the vehicle, for the routing services (as well as the other services).The complete enumeration and description of the devices, concerning all services offered to the driver, are stated in the chapter of embodiment (see "Peripherals"). Despite the fact that a device is used for a number of services, it is hereby stated that for the routing services [Fig. (1)] only the following are required:

* Data processing system that is a microcomputer (1) installed on board the vehicle,
* Peripherals (2), (3) - Memory unit (4), (5) and I/O unit, chronometer,
* Receiver (7)

From these devices, the use of receiver (7) in providing routing services, consists a novelty of the present invention whereas it permits the automatic input of

parameters and elements, in the data processing unit, affecting the routing service, such as:

* weather bulletin
* cartography of ports, parking spaces etc.
* road network traffic
* topographic reckoning of areas which are occasionally interesting (open pharmacies, Petrol Stations etc.)

This data, through the receiver, is processed by the processing system (1) which accordingly amends the selected course or selects a new one. The use of the chronometer as a device for the routing services consists another novelty of the present invention, whereas it permits the use of the time as a parameter for the determination and the set-up of a course. The routing services mentioned, from the start, which use the time element as a criterion, also use the chronometer for their embodiment. It is understood that those two devices are used, as mentioned before, for a number of services apart from the routing one.

Finally, in the memory unit (4), (5), elements of the road network, which allow the detailed registration of the network in such a way that the selection of the route is based on a wide variety of factors and data, are stored. For these elements of the road elements which are registered in the memory unit and are used by the routing services, as well as other services, the method provides for:

a. The storage, in the memory unit of the data processing system, of the topography of the road network in encoded form (that is storage of the road network in the form of a "graph" without reference to the geographical coordinates of the nodes) resulting in storage of extensive road network details in a low memory capacity.
b. The storage of the road network topography in levels, according to its significance and the distance covered by each arterial road. Therefore, arterial roads connecting countries of a wider area, are registered at first level,

arterial roads connecting cities of a given state are registered at second level, arterial roads interconnecting districts of city are registered at third level and the so forth.

c. The storage of auxiliary elements of the road network topography, i.e.
   * the slope of the road surface at, for example, every 100 meters of the course
   * the road surface quality
   * the available traffic lanes
   * the crossroads' formation, etc.

d. The storage of road signs, i.e.
   * the permanent road signs
   * the traffic lights
   * the length of a road section between two nodes
   * the name of a road section (street, avenue)
   * the numbering of buildings to the right or left of a street
   * the establishment of one-way streets
   * the seasonal or time changes of road networks' conditions

e. The storage of information concerning areas and buildings at both sides of the road network.

f. The storing of road network elements, which are time varying during a day or a week or even seasonally.

g. The topology of large crossroads or communication nodes like crossroads, large streets, multi-levelled crossroads, crossroads with bridges etc.

From this data, therefore, the data processing unit in order to set up a course:

* Takes into consideration the requirements of the driver,
* Takes into consideration the type of the vehicle (it is registered in the memory since installation),
* Takes into consideration the physical condition and the skills of the driver (as they will be mentioned in another service),
* Takes into consideration other factors (from the

receiver),

* Takes into consideration time and other constraints, whilst from the detailed elements registered in the memory unit, it specifies from the start every possible course that fulfils the above criteria, in a detailed manner for every part of the course, the conditions to be encountered by the vehicle or the driver, and from this detailed specification of every possible course, it selects the course best serving the target set by each service.

2. Vehicle Navigation Services during its circulation on a Road Network

By the term "Navigation Services" we signify the services aiming at the following two targets:

* The estimation and verification of the vehicle's real position on the road network.

** The driver's guidance on the manoeuvres he/she has to follow in order to follow a routing.

a. Position Estimation

The variety of services provided for the estimation and verification of vehicle's real position on the road network consists a feature of the present method. Each one of the position estimation and verification services use different methods so that each service complements and overlaps with the other. Therefore, in case of inaccuracy or failure on behalf of one of these services, the method always provides for the accurate estimation of the position by another service. The reason for this thorough examination of the position estimation issue, is the fact that the majority of the services provided to satisfy the driver's needs have to be supplied at the appropriate instant depending on the vehicle's position. If they are provided earlier or later than the appropriate instant, they are useless or hazardous.

The position estimation and verification methods, provided by the present method, are the following:

1) The confirmation of the vehicle's exact position on the road network by the driver, by means of a special verification and correction key, during vehicle's passage through distinctive positions of the road network e.g. nodes, turns, bridges etc.
2) Verification of vehicle's position by reception, from the vehicle's receiver, of signal of a nearby transmitter by means of a transmitter network installed on the road network.
3) Automatic estimation of vehicle's position on the road network, during a manoeuvre dictated by the topography of the road network, where the comparison of the road network topography and the method of manoeuvring confirm the vehicle's position, e.g. the passage of the vehicle from a turn is confirmed as soon as a steering wheel turn is verified.
4) Automatic correction of vehicle's position against inaccuracies at the distance measurement system (e.g. worn out tyres or tyres with low pressure) or at the measurement of arterial roads, taking into consideration corrective factors that depend on the repetitiveness of the error.
5) Use of odometers for measurement of the distance travelled by the vehicle where its position is confirmed upon integration of the travelled distance and of the directional wheels' angle of turn in order to verify the new direction of the vehicle after its arrival at a node.
6) Use of compass in conjunction with a subsystem of transmitters installed at traffic nodes in order to estimate vehicle's direction of entry at and exit from the node.
7) Use of longitudinal slope of roads in conjunction with the service of identification of vehicle's movement in acclivities or declivities in order to identify the vehicle's position. If the vehicle is ascertained (by a

service to be later described) to move at an acclivity, whilst the road network data expect a longitudinal ascending slope, is ascertained, then the vehicle's position on this particular part of the road network is verified.

8) Use of acoustic signal transmitted by the vehicle, which signal is reflected on buildings located at both sides of the road network, returns and is scanned by a receiver installed on board the vehicle for the purpose of verification of the vehicle's position in relation to the areas and buildings located at both sides of the road network.

9) Use of optical or other signal which is transmitted upon approaching at specified spots (turns, Petrol Stations etc.) with the view of having vehicle's position identified by the driver.

0) Finally, special services for the estimation of position, based on the processing of the odometer signal and the directional wheels transversal slope measuring device, allow the estimation of vehicle's position in areas which are not covered by the road network, such as unmapped areas, parkings, docks, deserts etc.

Apart from the initially mentioned characteristic of the methods of vehicle's position estimation and verification (that is accuracy and reliability by their overlapping, another characteristic of this method is that they resemble the methods used by the driver for his/her vehicle's position estimation. In fact, the driver, like the method, uses distinctive spots like nodes, Petrol Stations or other buildings, road surface formation (slope, turn), or sounds etc. in order to estimate his/her position. Due to this resemblance, the driver is in a position to ckeck the success of the position estimation or verification.

Finally, another characteristic of the said methods of vehicle's position estimation is that they cover every

possible formation of the road network and the areas and buildings located at both sides of the latter, by using every data available for position estimation. For instance, they use areas and buildings at both sides of the road network for urban centres coverage, or nodes for interurban networks coverage, or the longitudinal slope or other road formation for regional or provincial roads etc.

b. Guidance

By the term "Guidance", apart from the already mentioned supply to the driver of instructions and commands concerning the traffic along a route, we also signify every command or instruction concerning the carrying out of manoeuvres for any other purpose save the course along a route. The present method provides a variety of guidance services that satisfy driver's needs during various driving stages, at different sections of the road network and for various types of vehicles. From the start, a general service provided by the method concerning the mode of transmitting instructions and commands to the driver, has been stated. The method provides the following:

* AUDIO transmission of instructions
* VISUAL transmission of instructions
* BY THE SENSE OF TOUCH transmission of instructions

A characteristic of the modes of transmission of instructions is that they do not influence or distract driver's attention from its course, but they are communicated in such a way to accompany the driving. More specifically, for the guidance services, the method provides the following:

1) Transmission of commands and instructions by voice (e.g. "turn right", "attention STOP", "course in a square").
2) Transmission of audio signals (e.g. tone during the passage from nodes, sequence of tones of increased

sharpness when approaching a turn or a node, or tones and sounds to distinguish the extent of hazard of areas).

3) Use of a touch device in contact with a spot of the driver's skin, in order to transmit messages by the sense of touch. This device forms, for example, figures or characters by repeated pressure on various spots of the skin. The said touch device is described in the Application for Grant of a Patent No. 910100339/91.

4) Transmission of code words, code signals and messages by the sense of touch, in order to describe traffic nodes, e.g.

sound: Pi

figure: Π ...

message by the sense of touch: . .

. .

5) Use of two groups of blinkers installed in the right and left side of the driver's field of vision, the activation of which blinkers guides the driver to move and turn to the right or left.

6) Use of an indicator, which indicates the vehicle's position in relation to a frame denoting the surrounding area (street). While driving, the driver makes sure that the indicator remains within the frame. Thus, without visual contact with the surrounding area, the driver drives the vehicle within street limits.

7) Warning on the lane the vehicles moves in, or for the proper lane the vehicle should be placed in for its next proper movement.

With the view of guiding the drivers by audio, visual or touch messages, along a route, the method provides for the supply of instructions concerning the exact manoeuvres to be carried out at every route segment. For these instructions, the following are taken into consideration:

a) The road network topography as registered in the memory unit of the processing system.

b) The permanent traffic signs of the road network.

c) The auxiliary data of the road network.
d) The topology of large crossroads and traffic nodes, as they are registered in the memory unit of the processing system.
e) The manoeuvres that follow the next ones.
f) The vehicle's speed.
g) The physical condition of the driver.
h) The traffic signs and the road network topography that do not concern the next manoeuvres only but also the following ones.

The method provides the driver with accurate guidance through audio, visual or touch signals for the following:

1) The carrying out of manoeuvres or movements within special or limited areas, such as limited parking areas, at the entrance or exit of special areas e.g. ferry boats or multi-level garages. This is achieved by registering, in the processing system's memory unit, the special area or the initial and final vehicle's position, in which case the processing system estimates the course to be followed by the vehicle and informs the driver of the necessary manoeuvres.
2) The manoeuvres that concern special driving methods or address drivers of special categories (e.g. trainees or individuals with special needs requiring vehicles of special type). This is achieved by keying-in the driving specifications (e.g. minimum course speed, maximum course duration, minimum number of motor revolutions etc.), along with the road network topography, in which case the processing system estimates the necessary manoeuvres for vehicle's movement.
3) The correct manoeuvres depending on the road network topography and on the speed of the particular vehicle. Thus, in order to carry out any difficult or hazardous manoeuvre which is required by the topographic data of the road network, especially when the environmental conditions render the manoeuvre hazardous (e.g.

need to overtake a leading vehicle, need to turn when the road surface is slippery due to rain or need to drive fast under frosty or windy conditions), the processing system estimates the correct course to be followed by the vehicle and warns the driver about the proper manoeuvres required.

4) The correct manoeuvres depending on the type of the vehicle where the method is applied. This is particularly useful for the safe and correct driving of special vehicles, like ambulances, fire-fighting vehicles, trailers, buses and other vehicles, where the processing system takes into consideration, not only the road network topography, but also the geometry of the particular vehicle, the course of which is to be estimated by the system.

For the guidance services, the processing system maintains complete data about the road network, the driver's requirements, the vehicle and the driver's physical condition, just like in the case of the routing services. Therefore, it is capable of specifying the exact manoeuvres that the driver ought to perform along a route.

Apart from the AUDIO, VISUAL AND BY THE SENSE OF TOUCH transmission of instructions, another characteristic of guidance services is the following:

It has been stated that for estimating (one method) the vehicle's position, two "odometers" (devices for the measurement of wheel rotations and therefore of the travelled distance) and a device for measuring the directional wheels' transversal slope, are used. The said two devices are also used on certain guidance services. In this case, they are used in monitoring whether the instructions, communicated to the driver, were precisely followed. Thus, exact instructions may be communicated to the driver concerning vehicle's speed (e.g. 50 Km/hour), steering wheel turn (e.g. "turn right by 160 degrees"),

acceleration (e.g. "step on the accelerator by 3/4") and proper movement of the vehicle may be verified by the readings of the odometers and the transversal slope measuring device. If improper movement is detected, rectifying instructions are transmitted to the driver. In other guidance services, the instructions concerning manoeuvres are given gradually (e.g. "right turn ...turn ... turn .... STOP") until the proper manoeuvre is accomplished.

From the above, the next characteristic of guidance services is derived, which is user-friendly transmission of instructions to the driver in the same way as if they were given by a co-driver. This characteristic is particularly significant in case the driver is nervous and tends to react to irritations from the environment in a spasmodic way. On this point, a variety of services composed of a combination of ROUTING, POSITION ESTIMATION and GUIDANCE services and which concern the regulation of traffic problem of the urban centres, in order to avoid traffic congestion, is provided. The method provides solution to the traffic problem of large cities and the resulting problem of environmental pollution. In order to solve the traffic problem, the method provides for:

1) Information and guidance of the drivers by the traffic regulation agency e.g. by the traffic police or the police, in the following ways:

 * Through a central station of the agency from which messages are transmitted containing instructions, course modification recommendations, warnings and personal calls. These messages are accompanied by position codes or vehicles' identification, so that they are decoded and taken into consideration by vehicles of a particular position or identification.
 * Through sub-stations of the agency, installed at central points, that transmit messages when activated by the central station.

* Through portable transmitters of signals containing commands, recommendations and warnings, where the transmitters are installed at main locations and may be removed or relocated.
* Through portable transmitters of low range operated by employees of the agency, where the messages are addressed to the nearby moving vehicles.

2) Information and guidance to the driver, automatically, as follows:

* By messages stored in the processing system's memory concerning the rush hours of the arterial roads, special hours for circulation, repeated meetings etc. when the vehicle circulates in a particular arterial road at the time that the message refers to.
* By automatic selection of a new routing by the processing system which concludes that a traffic problem exists when the average driving speed of the vehicle is not provided for by the topographic data of the road network.

3) Use of the route finding methods by the driver when he/she feels that there will be a traffic congestion:

* By deleting from the initially selected course the nodes corresponding to the part of the route presenting the traffic problem.
* By cancelling the initially selected route and seeking a new one outside the congested area.
* By deviating through adjacent roads, causing an automatic rerouting.

4) Finally, selection (initially automatic) of the best route with the less possibility -according to the topographic and other data registered in the memory unit- of having traffic congestion at the time of and during the course.

3. Protection Services

In the course of the performance of protection services, the following are controlled in order to detect a direct or a future hazard:

* The physical condition of the driver
* The conditions of the surrounding area
* The vehicle's condition
* The vehicle's movement

In case of a hazard detection, following is provided for:

* Simple warning to the driver
* Instructions to the driver to avoid the hazard
* Warning to other vehicles about the hazard
* Automatic interference with the vehicle's system to avoid the hazard (e.g. immediate immobilisation of the vehicle)

Once again, like in the routing services, the main features of the protection services, are the automatic performance and their dynamic activation. By the term "automatic performance" we signify the hazard detection by the method without external or other interference. In particular, the hazard is detected by certain services much sooner than by the vehicle's driver or the drivers of other vehicles. As far as the dynamic activation is concerned, certain protection services are activated not only upon detecting a hazard during the vehicle's course, but as soon as the method merely detects conditions likely to endanger the vehicle or the driver. An example of protection activation is the automatic detection of driver's loosening attention due to fatigue. Those services are the following:

a. CONTROL AND PROTECTION DUE TO DRIVER'S PHYSICAL STATE

This service is provided on the following cases:

(1) Automatically, when the driver drives with his reflexes low due to intoxication, sleep, emotional state.

(2) Automatically, when the driver wishes to artificially keep his reflexes up (Driver's Artificial Alertness Service).

(3) Automatically, when the vehicle significantly deviates from the lane it is moving on.

(4) Automatically, when the vehicle significantly deviates from its course.

(5) Automatically, when a manoeuvre predetermines a hazard as in the case of blinkers' activation for turning to a prohibited direction, acceleration before approaching to a STOP sign etc.

The last three services concern an indirect driver's control in case he/she deviates from the course.

Moreover, the method provides a statistical driving manner control for a long period and warning to the driver when his/her driving manner predetermines hazards, providing the exact possibilities for causing an accident.

b. CONTROL AND PROTECTION DUE TO VEHICLE'S CONDITION

This service includes the following:

(1) Control in case of vehicle's excessive weight, due to load.
(2) Control and warning in case that lubricant or refrigerant are low.
(3) Control for wheel balancing need.
(4) Motor and electrical system tuning control.
(5) Braking system Control.
(6) Suspension system Control.

(7) Tyres' extent of wear Control.
(8) Tyres' loss of air pressure Control.
(9) Tyres' control in relation to vehicle's overweight.
(10) Directional wheels alignment Control.
(11) Directional System tightness Control (e.g. due to roll bar wear)

c. CONTROL AND PROTECTION AGAINST ADVERSE WEATHER CONDITIONS or BAD CONDITION OF ROAD SURFACE

This service includes the following:

(1) Control and protection against aqua planing.
(2) Control of and protection from road slip due to ice, oil, sand, gravel etc.
(3) Control and protection against heavy winds (frontwind, rearwind or sidewind)
(4) Control of road longitudinal slope and protection, for example, from hazardous declivity.

Particular feature of the present invention consists the fact that the abovementioned control is accomplished by the use of readings of two devices only, that is the odometer and the directional wheels transversal angle measuring device. These two groups of devices, as described, in detail, in the chapter of INVENTION EMBODIMENT, provide detailed information on the vehicle's motion in every part of the route, irrespective of its length. From the detailed control of the readings of the said devices, by comparing those readings with exemplary ones, the deviations from the normal course of the vehicle are identified and translated into e.g. bad driver physical condition, adverse environmetal conditions, bad vehicle condition etc. The advantages of the present method will be analysed in another chapter. Moreover, the method:

(5) Determines and warns about the proper speed of the

vehicle before it approaches traffic signs (e.g. STOP signs, traffic lights etc.). In case that the vehicle's speed or its position render the compliance with the traffic signs impossible, the nearby drivers are warned or the vehicle is automatically immobilised.

(6) Defines and warns about the proper speed in turns for safety reasons.

(7) Warns about the proper activation of the lights (e.g. in tunnels, at night time etc.).

(8) Warns when the vehicle is reversing.

(9) Automatically warns about a traffic sign (speed limits, prohibitions), about areas where parking is hazardous, about one-way roads, about allowance to overpass or not etc. This is accomplished by controlling the road network data and the vehicle's motion and position.

(10) Warns about increased alertness when approaching road network spots with increased rate of accidents.

(11) Warns nearby vehicles in case of collision.

(12) Provides instructions for coping with hazardous conditions such as vehicle's spin.

Those services are performed, as aforementioned, by comparing the data of vehicle's motion and manoeuvring with the road network data registered in the memory unit. For the most of the services, the vehicle's motion and manoeuvres are controlled by the readings of the odometer and the counter of directional wheels transversal angle. In every case, the instructions are provided by AUDIO, VISUAL or TOUCHING means, as in the guidance services. Finally, the method provides for four extra protection services, implemented by equivalent devices. Those devices are the following:

(13) Memory unit highly protected against mechanical, thermal, chemical or other influence, in which the date of vehicle's motion and manoeuvring during the last part of a course are registered and which is used for reproduction of the driving conditions during the last

part of the route travelled by the vehicle.

(14)Unit for uninterrupted vehicle's speed registration.

(15)Unit for the registration of traffic or prudent driving violations.

(16)Unit for vehicle's immediate immobilisation that uses the firing of a spear on the road surface that holds the vehicle by a wire cable in case that any other protection service fails to deal with the hazard. The immobilisation of the vehicle is automatic or manually activated by the driver.

4. Information Services

The information services cover the needs of the driver concerning communication with and identification of the surrounding area the vehicle moves in, whether this area concerns buildings and services or other vehicles. Apart from these needs, the information services also concern the vehicle's and driver's protection (e.g. against theft or assaults), the handling of emergencies (e.g. immediate call for an ambulance in case of a collision) etc. Thus, the method provides general information to the drivers on subjects concerning the surrounding area, as well as inter-communication of the vehicles through messages received by each vehicle's receiver which are transmitted by:

* central information and control stations,
* transmitters installed along the road network or in areas or buildings on both sides of the road network,
* transmitters installed on board other vehicles.

The messages transmitted by the above sources, bear code numbers that describe a topographic position, a time period, the identification or type of vehicle. Thus, those messages, depending on the said three code numbers, concern the following:

* all vehicles within the range of stations and

transmitters,

* vehicles moving towards the location specified by the messaged position code,
* vehicles, the size or type or identification of which, is determined by the identification code (e.g. trucks, ambulances etc.),
* each one of the above three cases but for a certain time period or duration,
* combination of the last three above mentioned cases that the transmitted messages concern.

The transmitted messages concern the following:

a. regulation of the traffic problem, as aforementioned
b. obstacles on the road surface due to acidents, road works etc.
c. Emergency calls to ambulances, police cars etc.
d. warnings for passing of stolen vehicle's.
e. warning for new road signs, prohibited driving zone etc.
f. advertisements on areas and buildings on both sides of the road network.
g. professional areas for emergencies such as pharmacies, first aid stations, Petrol Stations etc.
h. warning for areas or buildings with the purpose to guide and advise on the necessary manoeuvres for correction of the course (such as school ahead, to reduce speed, hospital for reducing the noise, passing through of a procession to intensify the attention etc.)
i. archaeological sites or of touristic interest etc. (educational messages).

E. ADVANTAGES OF THE PRESENT INVENTION

In the chapter of "Disclosure of the Invention", the particular features of each group of services have been given. These features are:

* Routing

* Position Estimation and Guidance
* Protection and Control
* Information

and they consist novelties and advantages of the present method. In this chapter, the general advantages of the method will be mentioned. These advantages refer to:

* the services provided
* the means for their embodiment

and concern the method either separately or in comparison to the state-of-the-art methods. These general advantages are the following:

1. *The completeness of the method*

The method covers a variety of driver's needs and provides a plethora of solutions on problems encountered during driving. None of the state-of-the-art methods and systems provides such a variety in relation to services provided and needs covered.

2. *The simplicity of method's operation principles*

Examples of operation principles simplicity consist the control of driver's physical condition, of environmetal conditions and vehicle's condition, which control is based only on the comparison of the data concerning vehicle's motion and the standard measurements. The-state-of-the-art inventions, in order to achieve the same services use complex methods and systems. The guidance services (e.g. course indicator, right and left blinkers etc.) consist another example of simplicity of operation principles.

3. *The user-friendliness to the driver*

The services are provided in a distinctive way e.g.

acoustically or by touching, without distracting driver's attention. A lot of services accompany the driver to the various needs he/she has, e.g. routing towards successive destinations, assistance on parking within limited space, guidance through areas not covered by the road network etc., and serve him replacing a co-driver.

4. *The "integrated form" of the method*

By the term "integration of the method" we signify that with the view of providing the plethora of services, the method requires the combination of a small number of devices, in such a way so that each device's function is influenced by another's function and each service provided supplements another. As aforementioned, examples consist e.g. the receiver participating in a variety of routing, protection and information services, the odometers and the directional wheels transversal angle counter, that participate in most of the position estimation, guidance and protection services. The services of position estimation, supplementing one each other or the other services, consist another example of the integration services.

5. *The automatic activation of the services and the dynamic character of the method*

The services are provided automatically and dynamically without driver's intervention or annoyance. The method provides for the automatic activation of each service and is based on its active participation in every phase or driving need. The aforementioned guidance and routing services consist examples thereof.

6. *The reliability of the method*

Due to overlapping between the services provided, the method is extremely reliable with almost eliminated possibility for

error, either on the time or correctness of the services provided. Another reason that guarantees the reliability of the method is the simplicity of its operation principles, mentioned hereinabove. Moreover, the method has self-control and self-correction ability, eliminating thus the errors or failures during its operation.

7. *The promptness and immediacy of the method*

The method provides the services promptly and immediately. It is a fact that the activation of each service does not require complicated or time-consuming estimations or combinations but consideration of the factors in the fastest way. The protection services is an example of this fact, since they require consideration and analysis of the readings of the odometer and counter of directional wheels transversal slope, only for a very small part of the route.

8. *The practicality and usefulness of the method*

The method is practical and usefull as it provides solutions on common problems daily faced by the driver, such as parking in a limited space, avoiding a traffic congestion, timely arrival at a predetermined destination etc.

9. *The social services of the method*

The method has a social impact as it affects other needs of the social life, apart from driving ones, such as the financial support of difficultly accessible areas by the routing services, the professional support of e.g. taxi drivers or truck drivers, the fighting of violence etc. It also offers a social service by the completeness of protection provided against the accidents, which consist an important problem of the modern societies. The method extends the individual activities (professional, social etc.) within the driving time, by rendering it from time lost, as in the inventions of the state-of-the-art, to

productive time (e.g. routing to successive destinations, communication, educational or updating information etc.). The vehicle and the driving period are promoted into means of satisfying the individual needs e.g. touristic, professional, commercial or advertising ones, offering education and accompanying the driver at the same time.

Moreover, the method does not isolate the driver, but in the contrary it brings the driver into contact with the surrounding area and the other drivers. Finally, by the use of information services, the vehicle becomes a tool for providing services to the society.

10. *Assistance provided to the driver by the method*

The guidance and protection services of the method artifially support the driving capacity of every individual, improving his/her efficiency. Also it assists drivers realise their responsibilities and the hazards entailed by reckless driving e.g. by the service of statistical accident rate, indicating the hazardous areas or by the unit of traffic violations registration etc.

Moreover, the method assists in those phases of the driving where no other method of the state-of-the-art or generally no assistance could be provided for, e.g. services for vehicle's spinning, control and protection in case of ice on the road surface etc. Finally, it offers relaxation to the driver during driving.

11. *The universality of the method*

The method addresses to every individuals irrespective of age, sex, profession, mentality etc. It gives another dimension to the driving issue, inducing experiences that up to date a few capable drivers only have e.g. providing instructions for race driving, for special driving methods (guidance under specifications).

12. *The "personal character" of the method*

The method has a "personal character" as it concerns every time a particular vehicle and a particular driver, e.g. by the service and the driving method of specific vehicle's type or each vehicle separately when inputting the vehicle's type in the memory unit or by the ability to identify special characteristics of the driver etc.

13. *The experience provided to the user by the method*

The method stores and provides the user with the experience accumulated from driving experience and vehicle's potential analysis.

14. *The money-saving potential of the method*

The method, for its implementation, uses simple and relatively low technology devices, reducing thus the cost and increasing its reliability. It also controls the vehicle, its condition and performance in a simple and low-cost way.

The state-of-the-art methods use complex methods and expensive devices.

15. *The "unlimited" application of the method*

The method is applied everywhere, at every crossroad of road networks and every area (urban centres, provincial roads, sub-urban networks) without limit, using the data of each particular area to provide services.

16. *The adjustment ability of the method*

The services provided, are adjusted to match the driver's ability to understand e.g. nodes, exact instructions of manoeuvring etc. and they do not consist mere commands.

17. *The control and protection provided by the method*

a. The method provides protection and control wherever the other state-of-the-art methods fail e.g. control of driver's physical condition.
b. It controls the vehicle's condition and performance in a simple way, unlike the other state-of-the-art inventions that apply complicated methods.
c. It controls and protects against adverse weather conditions and bad road surface situation, in a simple way, when the state-of-the-art methods are unable or require high cost to achieve it.
d. It controls the weather conditions without having a subsystem installed alongside the road network.
e. It controls and protects even in case of a possible accident and not only when a hazard is determined.
f. It provides the ability of immediate and effective vehicle's immobilisation, unlike the state-of-the-art methods.
g. It controls the safety of manoeuvres carried out by the driver and protects or notifies in case of danger.

Particular advantages concerning each service separately, as well as the advantages of methods of embodiment, will be given separately in the chapter of the Embodiment of the Invention.

F. EMBODIMENT OF THE INVENTION

The embodiment of the method is divided into eight sections:

a. PERIPHERALS
(description and function of the method devices).
b. DATA STRUCTURE
(Data and its method of registration and recall from the on-board microcomputer's memory unit).
c. ROUTING
(Vehicle's routing which includes the function of estimation

and selection of the vehicle's route).

d. NAVIGATION

(Exact vehicle's position estimation on the road network at every instant, position verification during the course, guidance for course along a route).

e. PROTECTION

(Warning, guidance and protection by the use of (1) two sensors i.e. of the odometer and steering wheel, (2) one sensor i.e. of the steering wheel, (3) one sensor i.e. of the odometer, and a table and (4) one sensor, i.e. of the odometer).

f. DRIVING METHODS

(Special driving methods, that is parking in narrow spaces, race driving, loading - unloading etc.).

g. REGISTRATION OF HAZARDOUS SITUATIONS

(Registration of special data and warning on accidents, thefts etc.).

h. INFORMATION

(Information to the driver concerning touristic, commercial, professional, topographic and other data).

The aforementioned sections are analysed herebelow:

a. <u>PERIPHERALS</u>

1. <u>List of Method Embodiment Devices</u>

Those devices are (Fig. 1):

(a) Data Processing Unit (1), that is a microcomputer installed on board the vehicle.

(b) Communication devices between driver and processing unit (2).

(c) Devices installed on board (3) for the control of its motion and the communication between vehicle and environment.

(d) Memory unit (4) for registration of the surrounding area data.

(e) Memory unit highly protected (5) for recording the

driving conditions.

(f) Device for the immediate immobilisation of the vehicle (6) in order to avoid hazardous situations.

(g) Receiver (7) installed on board the vehicle.

(h) Moreover, the method provides for the installation of a subsystem of transmitters (8) of limited range and number.

The devices (2), (3), (4), (5) and (6) are connected to and controlled by a microcomputer (1).

2. Enumeration of in-Vehicle Devices

It has been mentioned that a feature of the method is the use of a limited number of devices for a plethora of services provided to the driver, depending on the function analysis of every device by the on-board processing unit.

The ideal number of devices, installed on board, in order to provide more functions and services to the driver, is four. In view of the importance of the service provided, it is however considered absolutely essential the addition of a fifth device, although it provides an extra service. More specifically, during the embodiment of the method, the below mentioned in-vehicle devices are required (Fig. 2):

(a) Measuring device of the number of rotations of, at least, one rear wheel (10).

(b) Measuring device of the number of rotations of, at least, one front wheel (9).

(c) Measuring device of front directional wheels transversal slope (11).

(d) Receiver (7) of messages transmitted by transmitters' network (8), externally installed.

(e) Immediate vehicle immobilisation device (6).

Apart from these devices, which are considered absolutely esstential for the embodiment of most of the functions

supporting the drivers, the method in a second embodiment provides for extra devices, depending on the supporting services provided, being:

(f) Compass for estimation of vehicle's axis orientation.
(g) Box for the protection of the memory unit (5) and the safe storage of information.

The devices that need to be further described, are presented herebelow:

3. <u>Driver Interface (Display)</u>

It refers to a display presenting the data in the following forms:

* Characters, texts, etc.
* Symbols
* Figures, letters

The form to be used for the transmission of a message or the communication of an information varies according to the service provided by the method. The method of visual presentation is to be examined in the presentation of method supporting functions. Indicatively, it is mentioned the use of display for drivers' blind guidance. During this function, a small cycle and a dot with cruciform ends (Fig. 3) appears on the display. Those two spots appear in a square frame. In this figure, the dot represents the vehicle's real position, whilst the cycle represents the imaginary position concluded by the road network topography data and the regulations for safe driving. When the vehicle's driving coincides with the imaginary one, speedwise or directionwise, the dot appears within the cycle. When the vehicle's speed is higher or lower the imaginary one, the dot moves off to the upper or lower part of the display respectively. Likewise, a divertion to left or right of the imaginary course, corresponds to the dot's

removal to the left or right of the cycle on the display. In this way, by accelerating or decelerating the vehicle or by turning the directional wheel, the driver is in a position to drive his/her vehicle properly, just watching the dot's position in relation to the cycle on the display and without having visual contact with the environment. This method of blind routing will be explained in detail in the chapter of NAVIGATION of the present embodiment where the guidance service by route indicator (Paragraph 45) is also set forth.

4. Travelled Distance Counters (Odometers)

They are devices measuring the roations of at least one wheel of the vehicle. The readings of wheel rotations are input as a constant data to the processing unit. The number of rotations of a non-driving wheel multiplied by the perimeter of the wheel, indicates the distance travelled by the vehicle, in case that there is no slip of wheel on the road surface. This distance, divided by the time unit, indicates the speed of the vehicle. Figures (4) and (5) show the parts of the vehicle suitable for measuring the roations of driving or non-driving wheels. Finally, for the wheel rotation measurement, the below mentioned embodiment was chosen:

A sensor is used, which is activated when a material passes at a small distance. Examples of such sensors are the capacitors, the capacity of which changes when a metal piece approaches them. Another example of such sensors is the passing of electrical current by an inductor, when a magnet passes by. The technology of these sensors considered to be known and it is not reported herein. It is merely stressed that the signal of these sensors is almost relative to the distance where the piece of material is passing through. Figure (6) shows a diagram of such a sensor's signal during passing through of metal pieces.

A feature of the present method, which is also an advantage

against others, is the fact that uneven metal pieces (at least 3) when passing in front of the sensor, successively, transmit 3 signals of different duration (or strength if the metal pieces are installed in different distance of approach, at another embodiment). The successiveness of the signals shows apart from the wheel rotation (e.g. one rotation corresponds to every 3 signals), the direction of vehicle's motion (straight ahead or reverse). It means that if the duration of the signals transmitted by the three metals is I, II, III, then the microcomputer receives the signals from the sensor at the following order:

I - II - III - I - II - III - I - II - III

that is I - II - III
II - III - I
III - I - II
then the vehicle moves ahead.

If, however, the signals received are successively:

III - II - I - III - II - I - III - II - I

that is III - II - I
II - I - III
I - III - II
then the vehicle reverses.

During the present embodiment, metal pieces are arranged within a certain range on the wheel rim (Figure 7). At least 3 uneven metal pieces are used. The said three metal pieces are placed in such a way so that the wheel balancing is not affected. Figure (7) shows a schematic representation of proximity sensor and metal pieces arrangement. Figure (8) shows a realistic arrangement of the sensor on a real vehicle suspension system. The sensor is placed on a part able to sense the wheel rotation, such as the suspension.

In a second embodiment, the metal pieces are placed, when it regards driving wheels, on the power transmission shaft and on the differential gears. Figure (9) shows possible arrangements of the sensor and metal pieces. As mentioned before, the measurement of rotations per time unit, multiplied by the wheel perimeter consists the vehicle's speed. The estimation of vehicle's speed, therefore, during the instants t1 and t2, results to the number:

$$\frac{u2 - u1}{t2 - t1}$$

and consists indication of the acceleration γ of the vehicle.

5. Directional Wheel Angle Counter

Possible positions of the device are given in Figure (10), where a schematic representation of the vehicle's directional system and possible positions of the transversal angle measuring device is shown. The device is connected by an elastic belt or directly with the components of the directional system. Feature of the method is the sensitivity of measurement, so that the slightest change of wheels' direction is registered in the vehicle's microcomputer. Another feature is the immediacy of measurement as the vehicle's turn on the road surface requires transversal angle of turn of the wheels. The measurement device of directional wheels transversal angle plays a multiple role in the present method:

(a) It is used in the estimation of vehicle's position and the direction of its motion.

(b) By measuring the transversal slope, it provides instructions to the driver, easily, concerning necessary manoeuvres. In this way, for example, when instructing on parking manoeuvres (see Chapter f - Par. 88) the microcomputer guides the driver on the exact turn of the

steering wheel.

(c) Another example of using the measurement of directional wheels transversal angle in providing instructions to the driver, consists the guidance method with the COURSE INDICATOR (see Chapter d - Par. 45).

(d) The measurement of directional wheels transversal angle is also extensively used in the methods for the driver's protection against accidents (see SPINNING, SIDEWIND, PERFORMING A TURN etc.).

(e) Finally, the sensitivity of measurement of directional wheels transversal angle, is used for the control of the vehicle's condition (see Chapter e - Par. 60). In the majority of supporting services, the measurement of directional wheels transversal angle is used to dynamically support the vehicle's driver, due to the immediacy of the measurement. As aforementioned, the directional wheels angle indicates the vehicle's direction at a SUBSEQUENT TIME INSTANT. In this way, the microcomputer has time enough to provide instructions on situations to be encountered by the driver in the NEAR FUTURE.

From the known examined systems, there is none that uses the measurement device for wheels slope in order to provide instructions to the driver or to control and protect the vehicle. The use of directional wheels transversal angle measurement will be reported here in conjunction with the odometer's readings for the determination of vehicle's position.

b. DATA STRUCTURE

6. General Memory Data Structure

The data registered in the memory unit of the vehicle's microcomputer, constitute the second most important part of the embodiment of the invention. The devices presented in the last chapter constitute the sensors and units of communication and action of the microcomputer. Its memory

unit data forms the complete field, where the microcomputer collects information that decisively affect the instructions and actions indicated by the microcomputer. Thus, the correctness of instructions and actions indicated by the microcomputer, directly depends on the completeness and size of data stored in its memory unit. The present invention allows storage of data that completely cover the needs of drivers, irrespective of vehicle type and driver's efficiency, and, in addition, the drivers' needs for information and communication, which are related to the vehicle's usage for professional, recreational and other purposes. Thus, the driving time is upgraded to educational, recreational and professional time, which is particularly useful for individuals driving for extensive periods. The data, stored in the microcomputer's memory unit, are the following:

(a) Road network topographic data (nodal representation)
(b) Road network supporting data (slope, width, curvature etc.)
(c) Road traffic signs
(d) Information concerning areas and buildings at both sides of the road network
(e) Time varying road network data
(f) Topology for nodes and crossroads (complex, multi-levelled nodes)
(g) Various messages

The registration of this data into the memory unit of the microcomputer is effected in such a way so that the data are quickly retrieved. Moreover, despite its size, the data occupy the least possible memory space.

7. Additional Memory Data (Encoding of Messages)

(a) Node Code Numbers

The node code numbers are selected for each level, in such a

way so that they characterise the area they refer to. Therefore:

- For the level of nodes A of an inter-state network, a uniform code structure, applying to every state, is selected.

For example, IT-15
IT-28 for Italy
IT-39

GE- 5
GE- 8 for Germany
GE-14

- For the level of nodes B of an inter-urban network, a uniform code structure, applying to every prefecture or district, is selected.

For example, AT-19
AT-92 for the inter-urban network of the
AT-18 prefecture of Attica

KA- 5
KA- 9 for the inter-urban network of the
KA-34 prefecture of Karditsa

- For the urban network, a uniform code is selected applying on every city and so forth.

(b) <u>Abbreviated characterisation of course sections between two nodes and node characterisation</u>

The characterisation of every course section and node by grades is provided, e.g. 0-10, whilst the grade describes the ACCESSIBILITY from that part of the route.

The ACCESSIBILITY of a part of the route, characterises the

average speed by which a vehicle may go through that part of the route, depending on a variety of factors, such as:

- Topographic data of road surface (available width, quality of road surface)
- Traffic signs
- Type of vehicle, referred to
- Area of vehicle's movement
- Other data

Among the data, affecting the ACCESSIBILITY of a part of the route or a node, there are the vehicle's type and driver's efficiency. Thus, a part of the route with accessibility grade 10 for a small vehicle, it corresponds to 0 (zero) when it refers to a large vehicle in case the part of the route includes an area where the large vehicle transit is forbidden. For this reason, in order to register the accessibility grade of each part of a route, additional data concerning the user or the vehicle are required.

In case the accessibility grade is not used, the topographic data and the traffic sign data suffice for the microcomputer to attribute accessibility grades for each type of route. Similar accessibility grade is attributed to nodes depending on their topographic data. Thus, the vehicle's microcomputer by working during the time that it is not used on supporting operations, processes the detailed road network data and registers the accessibility grade of each part of the route, in a special position of the memory unit or in a special memory unit, and, thus, offers a group of data allowing the fast control, if the course towards a specific destination is recommended for the particular vehicle or driver.

8. <u>Messages and Information in the Memory Unit</u>

In a special position of the memory unit, messages of various types servicing driver's different needs, are stored.

Such needs may be the following:

* Professional
* Educational
* Recreational
* Precautional
* For intensified attention
* For communication purposes

etc.

Every message is initially registered bearing a code number. In a first embodiment of the method, a code number of different nature for every type of message is provided. As aforementioned, this part of the memory unit is used for the communication of in-vehicle devices with transmitters installed along the road network or on board other vehicles, buildings or areas. The reception of an encoded signal, by the in-vehicle receiver, refers to this part of the memory unit for the translation of the signal into the transmitted message. However, apart from the said use, all the instructions, which address to the driver for supporting driving, are stored in the position of the memory unit, under consideration, e.g.

- TURN RIGHT
- ATTENTION, TRAFFIC LIGHTS

etc.

Finally, there exist message code numbers in all previous registered data, so that the microcomputer when editing other data, upon encountering a message code number, refers to this part of the memory unit and transmits the respective message. Moreover, if this part of the memory unit is common to all vehicles disposing of said supporting method, the exchange of messages between drivers is achieved by the exemption of particular code numbers. Table (1) shows examples of messages which are registered in this part of the memory unit, along with examples of code numbers

M-14	ATTENTION - ICE ON THE ROAD SURFACE
M-15	REDUCE SPEED
P-18	ENTERING INTO A TUNNEL. TURN LIGHTS ON
P-35	RIGHT WHEEL UNBALANCED
P-48	APPROACH TO A Y-TYPE NODE
E- 1	MUSEUM OF BYZANTINE ART. IT EXHIBITS ARTICLES OF THE 10TH TO 15TH CENTURIES
E- 9	MUSEUM OF MODERN ART. THEY EXHIBIT FOLLOWING: ...

MESSAGE CODE NR.	TEXT

TABLE (1) - AN EXAMPLE OF MESSAGE REGISTRATION INTO THE MEMORY UNIT

accompanying the messages.

9. Registration of Road Network (Topology)

The road network of an area is registered in the memory unit, in such a way so that the real needs of the driver are served. It is proved that this method is the most economical from the point of memory size required and the most easy to use from the point of guidance functions that it serves. Thus, in practice, the driver is slightly interested in the coordinates of the area, he/she is located at, or the destination point he/she is moving towards. In fact, the driver's interest is focussed on the traffic nodes (crossroads), where he/she has to select which direction to follow and the sections between nodes which he/she has to cross.

With this reasoning, the road network is registered in the memory unit in the form of a graph, that includes as nodes the traffic ones (crossroads) and as branches the sections of roads between two nodes. Thus, the "topology" and not the geography of the road network is registered. In this way, each node is connected to the adjacent ones by branches, providing thus to the driver the image of the road network he/she mostly needs, that is, the nodes towards which he/she has to move upon arrival at each node. Figure (11) represents the embodiment of the registration method of road network topology. This figure presents the real picture of the road network A (for example, as it appears on a road map), the topological picture, as registered in the memory unit of the processing system B, as well as the method of connecting nodes C, where each node is connected with other nodes, in a rational order. The features of the topological representation of the road network are the following:

(a) It requires minimal memory size, as it needs only the registration of node code number and the method of their connection. The node code numbers, in a first embodiment,

are integer numbers. In this way, the topography of large areas (like countries or continents) is registered on a limited memory size and there is no need to use additional data memory units (only for the road network topology).

(b) It does not require geographical coordinates of the nodes or sections of roads between nodes. In practice, the registration of geographical coordinates of the road network covering greater areas (such as continents) is impossible as it calls for the two-dimensional flat representation of road network points, whilst they are located on the globular earth surface. On the other hand, the representation of the road network points, with respect to the geographical longitude and latitude, provide the driver with scant practical use. In this way, that is without reference to the geographical coordinates, the topological representation of the road network is easy and fast.

(c) The registration of topology in a small memory extent, provides to the data processing system a full picture of the database of a greater area within the road network. Having this database, the microcomputer is able to organise and form the instructions to be provided to the driver, so as to cover his/her needs concerning any distance of the course. Examples of such an organisation and instruction formation are the following:

* instructions concerning supply of data storage units (e.g. diskettes), covering the sections of a course.
* instructions concerning the proper moment of using each of these units (e.g. upon entering into a certain city, the system notifies the user to insert the proper diskette).
* instructions concerning the organisation of stops and overnight stays.

10. Topology of Nodes and Crossroads

As aforementioned, every node of the road network is

characterised by a code number. The driver, following the section of a route between two nodes, arrives at a particular node and thereafter he/she follows a new route. For simple nodes (e.g. simple crossroad of two vertical roads) the driver's manoeuvres, when transiting the node, are simple. Very often, however, the driver passes through nodes of complex geometry or multi-levelled ones, in which case the memory registration is a lot more complex in order to accurately guide the driver to the exit of a particular route.

The figures, as given herebelow, show the common traffic nodes and the elements accompanying each one. More specifically:

Figure (12) : Node formation elements
Figure (13) : Node elements of a main road
Figure (14) : Node elements of a secondary road
Figure (15) : Schematical representation of node elements
Figure (16) : Schematical representation of nodes
Figure (17) : Verbal node description
Figure (18) : Nodes in one level with three branches
Figure (19) : Nodes in one level with three branches
Figure (20) : Nodes in one level with three branches
Figure (21) : Nodes in one level with four branches
Figure (22) : Nodes in one level with four branches
Figure (23) : Nodes in one level with more branches
Figure (24) : Nodes in two levels with three branches
Figure (25) : Nodes in two levels with four branches
Figure (26) : Nodes in more levels with three branches
Figure (27) : Nodes in more levels with four branches
Figure (28) : Nodes in more levels with four branches
Figure (29) : Node registered elements
Figure (30) : Geometrical node elements
Figure (31) : Topographic node elements
Figure (32) : Registration of topographic node elements

The nodes, in a first embodiment, are registered in the

memory unit with following features:

(a) Verbally, as in figure (17). In this figure, the various nodes are described as follows, depending on the branches and levels involved:

Node types	Branches – levels
* Y-type node * T-type node * Star-type node	3 branches - 1 level
* Trumpet-type node * Double trumpet-type node * Combination of the above	3 branches - 2 levels
* Triangle-type node * Star-type node	3 branches - 3 levels
* Clover-type node * Circle-type node * Propeller-type node * Turbine-type node	4 branches - 4 levels

and the so forth.

Each name denotes the special features of a node. Figure (17) gives the nomenclature of nodes.

(b) Topological registration of nodes

The topological registration of nodes is shown in Figures (24) to (28) and it concerns complex nodes of various levels and branches.

The same figures show the names of nodes as given in the previous method. The registration is effected schematically, that is the form of the node is registered in the memory unit.

(c) Geometrical registration of nodes

The geometrical registration of nodes is shown in Figures (18) to (23). In these figures, the traffic congestion, the traffic flow (continuous or interrupted) and the geometrical form of the crossroads, are shown. Each branch, to which the node is forked, is described by the latin letters A-B-C-D. The figures show the method of registering the nodes in the memory unit, that is by geometrical representation and symbols of the nodes, with which the branches communicate. Thus, for the particular node of an area, e.g. node 64, the letters A, B, C, D, etc., correspond to the connecting nodes, e.g. A–>55, B–>64, C–>75.

(d) Presentation in detail

A detailed presentation of the nodes with topographic elements is given in Figures (29), (30) and (31). More specifically:

Figure (29) A: Determination of speeds in the various node sections.
B: Traffic lanes in the various node sections.
C: Curvature radii and hypsometrical differences in the various node sections.

Figure (30 : Curvature radii in the various sections of ordinary nodes.

Figure (31) : Transversal and longitudinal slopes of node sections.

An example of node registration in the database, according to the above embodiment, is shown on Figure (32). In this figure, following are presented:

Position 1: Node code number
Position 2: Symbol
Position 3: Geometry
Position 4: Flow diagram

Position 5:	Entry branch (into a node)	
Position 6:	Exit branch (from a node)	
Position 7:	Distance travelled inside a node	
Position 8:	Period of topographic elements receiving	
Position 9:	Available width	during entering
Position 10:	Quality	
Position 11:	Transversal slope	
Position 12:	Longitudinal slope	
Position 13:	Curvature	
Position 14:	Available width	during the first period of topographic measurements taking
Position 15:	Quality	
Position 16:	Transversal slope	
Position 17:	Longitudinal slope	
Position 18:	Curvature	

and so forth.

The indicated topographic elements are identical to those of an ordinary road network.

11. Road Network Topography (Slope, Width, Curvature etc.)

These elements exclusively refer to the road network topography and concern sections of the road network connecting two adjacent nodes. By the term "topography" we signify the elements connected with the physical configuration (geometrical features) of the said road network sections (i.e. length, available width, slope etc.) and not with their technical features (i.e. traffic signs, one-way street, names etc.). These topographic elements that concern every course section between two nodes are:

(a) The travelled length between the departure from one node and the arrival to another one, that is the distance travelled between two nodes.

(b) The road surface width available for the vehicle circulation, which is characterised by the transverse

distance which is available in road sections of one traffic lane. For more available traffic lanes, the number of lanes is mentioned. It has to be stressed that the available road surface width does not always coincide with its geometric width. For example, if car parking is allowed at the edge of road surface, the width taken by the parked vehicles is deducted from the respective geometric width and the balance is stated to be the width available to the circulation. Again, if the roadsides appear to be eroded, the part affected by erosion is deducted from the road width. The road width is registered at fixed route intervals (e.g. every 50 m.).

(c) The road surface quality is characterised by a scale number ranging from 0 to 10. Table (2) presents the road surface quality which corresponds to this scale. It is therefrom concluded that the perfect road surface condition corresponds to the scale number 9, whilst the absence of minor uneveness could be the cause of hazardous slipperiness. Thus, grade 10 indicates possible hazards and drivers' attention is drawn thereon. The road surface quality is registered at fixed route intervals (e.g. every 50 m.).

(d) The transversal slope of the road surface, measured in degrees and denotes the vehicle's transversal inclination against its vertical plane to the right of its course, in which case it is characterised as negative, or to the left of its course, in which case it is characterised as positive (figure 33). The road surface transversal slope is registered at fixed route intervals (e.g. every 50 m.).

(e) The longitudinal slope of the road surface. The declivity and acclivity of the road surface are measured in degrees, with reference to the vertical axis, at fixed route intervals (e.g. every 50 m.). The declivity is characterised by a negative slope angle, whilst the acclivity by a positive slope angle. For example,

0	UNEVENESS HEIGHT: ABOVE 10 cm Roads only accessible by heavy type vehicles(tractors, jeeps, trucks)
1	UNEVENESS HEIGHT: 8 - 10 cm Roads accessible with difficulty or at low speed
2	UNEVENESS HEIGHT: 5 - 8 cm Roads accessible at low speed
3	UNEVENESS HEIGHT: 3 - 5 cm Roads accessible with caution
4	UNEVENESS HEIGHT: 1 - 3 cm Roads accessible at moderate speed and vibrations
5	UNEVENESS HEIGHT: 8 mm - 1 cm Bad quality road surface for moderate speeds
6	UNEVENESS HEIGHT: 5 - 8 mm Bad quality asphalt
7	UNEVENESS HEIGHT: 3 - 5 mm Moderate quality asphalt
8	UNEVENESS HEIGHT: 1 - 3 mm Good quality asphalt
9	UNEVENESS HEIGHT: 0.5 - 1 mm Ideal condition of asphalt
10	UNEVENESS HEIGHT: 0 - 0.5 mm Hazardous condition of asphalt. Hazardous slipperiness under humidity or heat

TABLE (2) - Road surface quality scale

longitudinal slope of +15 degrees indicates acclivity of 15 degrees against the horizontal.

(f) The route curving. It concerns the road deviation from the straight line and it is derived from the inverse of the road curvature.

$$\varkappa = \pm 1/\rho, \ \rho = \text{curvature radius}$$

The positive sign denotes curving to the left of the vehicle course and the negative sign denotes curving to the right of the course. The curving k=0 denotes straight course. An example of road network curving is given in Figure (34). Characteristics of the registration of topographic elements in the measurement unit, are the following:

(a) The simplicity of registration. Each section of the road network between two nodes is described by a sequence of numbers corresponding to topographic data. An example of such a sequence, is given in Figure (35). In the said example of Figure (35), the departure and arrival nodes are registered in the first and second positions of the available direction. In this way, the positive and negative signs (+, -) of the topographic elements are defined. In the next position there appears the overall length of the road, between two nodes, while in the next (4th) position appears the period of topographic elements receiving from the start (in this case every 100 m.).

Every five positions, the next ones cover the following:

* The available width in circulation lanes
* The quality of road surface at a scale
* The transversal slope in degrees
* The longitudinal slope in degrees
* The curving

every 100 m of the course, upto the end.

(b) The easiness of obtaining this data. Considering the road network topology, one vehicle is required to be supplied with:

* An accurate odometer (to measure the travelled distance)
* A counter of directional wheels transversal angle (to measure the road curving)

Figure (36) shows the method of estimating the road curvature radius on the basis of the transversal angle of the wheels.

* An accelerometer for measuring the vibrations and consequently the road surface quality
* An angle gauge for measuring the transversal or longitudinal angle.

If the above devices are connected to the microcomputer unit, through the proper software, the input of data may be carried out automatically and the vehicle is then used as a mobile unit for registration of topographic data.

(c) The importance of those elements is great, whereas they allow to the microcomputer to compare the data of vehicle's movement with physical environment parameters and transmit instructions concerning safe driving. Moreover, they allow the microcomputer to conclude in advance, whether a course is feasible considering the efficiency of the driver it addresses to.

The use of these elements for routing a particular vehicle or driver, for suppling instructions concerning manoeuvres, for monitoring or protecting drivers, will be analysed in the respective chapters.

12. Road Network Traffic Signs

It includes artificial (that is non-geometrical) features of

road sections between two nodes and it refers to various elements, such as traffic signals, one-way road, names etc. Those elements are in detail the following:

(a) The permanent traffic signs of the road network, which includes:

* STOP
* SPEED LIMIT
* NO RIGHT/LEFT TURN
* SLOW
etc.

Each traffic sign is registered with a code number in the data memory unit. An example of such code number, corresponding to specific signs, is given in Figures (37), (38) and (39). For example, the code number P-11 corresponds to entry prohibition for bicycles, while K-6 corresponds to hazardous one-sided narrowing down of the road.

(b) The existence or non-existence of traffic lights. These are usually installed on the arrival node. For the registration of the elements of the road network signs the existence or non-existence of traffic lights is represented by a character (e.g. F) next to the node number which signifies that upon arrival at this node, there exists a traffic light (e.g. 64F).

(c) Name of a street between two nodes. The real name of the road section between two nodes is represented by a series of characters (e.g. VELISSARIOU).

(d) Numbering of buildings located on the road section between two nodes (e.g. 68-108 for movement from node 3, for example, to node 5 or 55-99 for reverse movement.

(e) Establishing one-way streets which are represented by a simple character such as S, or D for double-way streets.

(f) Various other traffic signs, indicating the condition of a street section, which are placed on special occasions such as Dead-end, Deviation etc.

The registration method of these traffic signs is simple and it is carried out simultaneously with the topographic data of the road section between two nodes. An example of traffic signs registration method in the memory unit for a course section between two nodes, is shown in Table (3), where following are registered:

Position 1: Initial node
Position 2: Final node
Position 3: Partial course length
Position 4: Symbol for one-way or double-way streets
Position 5: Departure node
Position 6: Initial numbering of buildings located at the right side of the street, at vehicle's direction
Positions 6 and 7 : Regulatory sign symbol and distance from a departure node
Positions 11 and 12 : Street name, and so forth.

13. Areas and Building at both sides of the Road Network

The information and data that concern the areas or buildings at both sides of the road network are registered into the memory unit of the microcomputer in two ways, i.e.:

(a) as elements of street sections between two nodes,
(b) in groups, while each area or building is described by the course section between two nodes, that it is located at, or the distance from the departure node.

The said section of registration is combined with paragraph (8), where codes of various messages or information

INITIAL NODE	55
FINAL NODE	63
LEGTH OF COURSE SECTION	350
ONE-WAY OR DOUBLE WAY CIRCULATION	D
DEPARTURE NODE	55
INIT. NUMBER. RIGHT-HAND BUILDINGS	37
:REGULATORY TRAFFIC SIGN	P-14
:DISTANCE FROM STARTING POINT	100
:STREET NAME	ZENON
ARRIVAL NODE	63
EXISTENCE OF TRAFFIC LIGHTS	L
FINAL NUMBER. RIGHT-HAND BUILDINGS	105
DEPARTURE CODE	63
INIT. NUMBER. RIGH-HAND BUILDINGS	56
:REGULATORY TRAFFIC SIGN	P-4
:DISTANCE FROM STARTING POINT	150

TABLE (3) - SCHEMATIC REPRESENTATION OF ROAD NETWORK TRAFFIC SIGNS REGISTERED IN THE MEMORY UNIT

addressed to the driver are registered in. Thus, simultaneously with information, messages of any nature, such as advertising, guiding, educational, professional etc. which concern areas or buildings at both sides of the road network, are transmitted, e.g.:

* Shops
* Museums
* Banks
* Pharmacies
* Petrol stations
* Hotels
* Archaeological sites
* Churches
* Hospitals
* Police Stations

etc.

If the available memory units (diskettes) are sufficient, the whole professional telephone catalogue (Yellow Pages) of an area is registered in the memory units and is placed at the disposal of the driver. Moreover, any interested businessman may register an advertising or other message into the memory unit, which is announced when passing by the particular building or at the driver's discretion. In a first embodiment, the registration of these elements into the memory unit is effected as follows:

The data of a telephone or other catalogue is registered into a specific position within the memory unit, accompanied by a coverage of areas or buildings at both sides of the road network, which is as complete as possible. This data is registered by codes, each one of them describing a particular group of buildings, shops or areas, e.g.:

PHA = Code for Pharmacies
GAS = Code for Petrol Stations
POL = Code for Police Stations
etc.

Below the code of each group, there are listed the respective buildings or areas. At the beginning of each area position, there exist two code numbers which declare the two nodes, where the building in question is located in between. The first code number declares the node of entry into the course section and the second one the exit code, in order to find the building, in question, at the right side of the vehicle. After the two said codes, there follows a number which declare in metres (m), for example, the distance of the particular building from the entrance node. An example of such a registration is shown on Table (4).

According to this Table, in this embodiment, every particular shop, for example, belonging to a certain category, is described by a single symbol being the code number of entry or exit node or even the distance from the entrance node. In cases where more than one shop, for example, of the same category is registered in the same position, they are simply announced or registered one after the other. As shown on the table, the owner's particulars, the name of the company, the telephone number, the working hours or various messages that the interested owner may register, are listed along with the position number of each area. In this way, the whole catalogue of professionals is registered into the memory unit. This registration corresponds to item (b) hereinabove. In the sense of item (a), hereinabove, the codes concerning areas or buildings, are registered as road network elements and they are listed as in the attached Table (5). This table shows the description of each course from the departure code, the arrival node code and the course distance between two nodes. It also follows, successively, the area or building code and its distance from the starting point. The codes are placed in ascending order as the distance from the departure node increases. If more detailed information concerning an area or a building is required, the microcomputer refers to the second registration under the stipulated code, e.g. PHA or it founds the exact elements, from the entrance node, the

P H A								
45	54	50	BAKAKOS	9015355	8:00-17:00	SUNDAYS OPEN	50,RAL-LI P.ST
28	33	70	HYGIA	8017034	8:00-12:00 18:00-24:00	-	35, ZE-NON ST.
34	68	105	A.ZENON	6633194	8:30-17:30	-	OMONIA
101	19	19	E.NATSIS	5248192	9:00-18:00	EACH 3RD SATURDAY OPEN	50,STA-DIOU ST
336	402	25	A.PERIS	9914513	10:00-20:00	-	
9	15	105	IPPOCR.	6340817	10:00-18:00	-	
B E N							
11	51	100	FINA	3474843	7:00-19:00	LAUNDRY-LUBOIL CHANGE MARKET	GLYFADA
18	31	210	SHELL	6180359	7:00-19:00	SUNDAYS OPEN	PERIS-SOS

TABLE (4) - REGISTRATION OF AREAS OR BUILDINGS ON BOTH SIDES OF THE ROAD NETWORK

ENTRY CODE NR. (STARTING POINT)	30	44	68	34
EXIT CODE NR.	60	68	99	55
COURSE LENGTH (m)	250	180	500	360
:AREA OR BUILDING :CODE	SURG	GAS	GAS	PHA
:DISTANCE FROM A :STARTING POINT	50	100	150	100
:AREA CODE	GARD	FURN	ENG	SURG
:DISTANCE FROM A :STARTING POINT	80	120	250	190
:AREA CODE	POLIC	ARCH	FURN	CARP
:DISTANCE FROM A :STARTING POINT	100	130	300	200
:AREA CODE	SURG	ENG	GARD	CHUR
:DISTANCE FROM A :STARTING POINT	110	140	400	300
:AREA CODE	LEO	SURG	ENG	GARD
:DISTANCE FROM A :STARTING POINT	180	160	480	360

TABLE (5) - REGISTRATION OF AREAS OR BUILDINGS AS ELEMENTS OF THE ROAD NETWORK

exit node or the exact distance of the particular building. An example of such a detailed information is shown on Figure (40). As it is also shown on Figure (40), the code number of the area refers to the category involved e.g. shops, while the code numbers of entry and exit nodes as well as the distance from the starting point are enough, so that by a single symbol they declare the area or building concerned and transmit detailed information in connection therewith.

The user indicatively interfers with the transmission of information with the view of receiving information of his/her interest, as it will be described in detail in the chapter of information to or communication with the driver. As an indication of such interference, it is noted that the driver may select the kind of area he/she is interested in e.g. GAS for Petrol Stations or to receive information exclusively concerning Petrol Stations alongside a certain route. Moreover, the user may be guided from the point he/she is located at, to the nearest gasoline station, for example, by keying the proper instruction (i.e. GAS) into the microcomputer.

The characteristics and advantages of the said registration, are better described in the respective chapter of drivers' guidance and information.

14. Time varying Road Network Data

Apart from the other detailed data that concern buildings or areas of the road network, time varying data applying thereon are also registered. Such data is:

* Working hours of shops
* All night services
* Working hours during holidays
* 24-hours Work

etc.

However, various other road network data appear to have a time variation. Examples of such data are:

* Prohibition of parking during a certain time period
* Prohibition of access for certain vehicles during specific time period ("prohibited zone")
* Operation time of traffic lights
* Prohibition of passing through, due to a demonstration during a certain time period (e.g. parade)

etc.

The conventional traffic signs do not provide, in their majority, the duration of validity of each traffic sign. The driver is obliged to keep himself/herself informed of such a duration from the mass media, for example, as applies on the case of traffic restriction in the center of a city ("prohibited zone") or on the demonstration case, which interrupts contemporaneously the traffic e.g. a military procession on national anniverseries or Sunday football matches. The present method is superior to the state-of-the-art ones, since the microcomputer is fed with such data in its memory unit, which otherwise the driver would either ignore or know upon arrival at the location of occurence.

The registration of time varying data into the memory unit, in a first embodiment, is accomplished as follows:

It has been stated that the road sections between two nodes are initially characterised by:

* the entrance node
* the exit node
* the length of route between two nodes

Thereafter, depending on the elements registered, the below stated data follows:

* Topographic data (slope, curving)

* Traffic sign data (traffic signs, traffic lights)
* Area or building data

In case that a certain element is encountered in a particular course section, that concerns a special type vehicle or is time varying, two symbols follow right after the codes of departure or arrival nodes. Those symbols may be:

E—> For this route section, there exists a data concerning a special type vehicle

T—> For this route section, there exists a time varying data

Those symbols are inserted in each registration in accordance with the relevant elements, e.g.

* Topographic data
* Traffic sign data
* Areas or buildings (beyond the working hours)

In this first embodiment, the time varying information or data are registered in a separate position within the memory unit, bearing the entry or exit nodes as identification elements. Figure (41) represents such a registration of time varying data or data concerning special type vehicles. As it appears on Figure (41), symbol T refers to the section of time varying data registration.

The data registered in the course section with the same entrance and exit nodes, are then edited.

The data is transmitted on the basis of the distance from the starting point of the course and in the following order: Distance from starting point - Code of sign or building - Duration of validity or working hours.

c. ROUTING

15. Routing - General

The estimation and setting-up of the course to be followed by the vehicle in order to arrive at the destination, coming from an initial starting point, consists the basic supporting function provided by the method. In order to achieve this function, the road network data registered in the memory unit are mainly used, as described in the chapter b - DATA STRUCTURE - Embodiment of Invention.

It is repeated here that the said registered data is:

a) Road network topology (representation in nodes) [Chapter b - Par. (9)]

b) Supporting (geometrical) elements of the road network [Chapter b - Par. (12)], i.e.
   * Travelled length
   * Available width
   * Road surface quality
   * Transversal slope
   * Longitudinal slope
   * Curving of route

c) Road network traffic signs [Chapter b - Par. (12)]
   * Permanent Traffic signs
   * Traffic lights
   * Street names
   * Numbering of buildings
   * Directing the traffic in one lane
   * Various

d) Information concerning areas and buildings at both sides of the road network [Chapter b - Par. (13)]

e) Time varying road network data [Chapter b - Par. (14)]

f) Various messages and code numbers of transmitters installed alongside the road network

Furthermore, following data is available to the

microcomputer:

* the type of vehicle, that has been supplied with the present supporting method (passenger vehicle, truck, tractor, weight, dimensions, number of wheels etc.)
* details concerning the driver of the vehicle in question

On the basis of above data, the microcomputer estimates and sets up the course to be followed by the vehicle, provided that:

- the driver keys-in the destination
- the driver keys-in the present position
- the driver keys-in the specifications that the route should comply with

More specifically, as far as the data is concerned, the following applies:

(a) <u>Destination</u>

In order to "inform" the data processing system on the exact destination, the driver uses:

* either the keyboard (chapter d. - par. 42). Provided that the vehicle is immobilised, the driver keys-in the destination.
* or the tracing device (please refer to Application No. 910100339/91), through which the driver "informs" the microcomputer of the destination, even whilst vehicle is in motion.

The destination data given by the driver should be enough to enable the data processing system to accurately define the destination. This data is selected from the road network ones, being registered in the memory unit, as summarised at the beginning of the present chapter, under one restriction only.

* the keyed-in data should be enough in order to accurately define the destination (or successive destinations in case of consecutive courses).

Such data which is keyed-in whilst the vehicle is immobilised or traced whilst the vehicle is in motion, is:

(1) topological data of the road network and particularly the code number of the node.
(2) road network supporting data, namely

- course section defined by respective the code numbers of the two nodes and the length travelled from the first node where the starting point is.
- course section defined by the respective code numbers of the two nodes and an intermediate auxiliary point, such as distinctive road surface width, road surface quality, transversal slope, longitudinal slope, curving etc. E.g. defining the destination : The run between adjacent nodes 35 and 48. Points of run are curvature radius ρ=100m and transversal slope +10°. This method of position estimating is particularly useful to special type vehicles, such as fire-fighting vehicles, as it guides them through areas without distinctive marks either than the kind, i.e. rural roads, roads in the highlands or in the forests etc.

(b) <u>Road network traffic signs</u>

The driver keys-in, as destination data, certain data that concerns the course section e.g. course section between nodes 48 and 34, and moreover, with the view to define the exact point of destination, a distinctive point of the traffic sign network e.g. STOP sign, rail crossing point, bridge point, traffic light etc.

(c) <u>Street name</u>, for the determination of the course section along with an auxiliary element for the accurate estimation of the destination point.

Such element may be:

- Building Number
- Sign-post
- Distance from a distinctive node etc.
- Particular building or area, located in the course section, e.g. pharmacy, petrol station etc.

(d) Crossroad, in which case the microcomputer finds the code number of the node corresponding to the said crossroad.

(e) Distinctive area or building, that exclusively defines a point, e.g.

- Municipality House
- Ministry of Finance
- "Atlantis" Hotel
- Pharmacy of "D.Elpinikos"
- "MINION" department store
- St. John's church

In case that the distinctive area or building is not enough to define the point of destination, the location is also inserted, i.e. name of suburb, name of city, name of region etc. On the basis of these elements, the data processing system selects from the database the exact position of the point of destination.

(f) Distinctive node topology on the road network, e.g. a node of double propeller, of turbine etc. The destination is finally registered or edited by the microcomputer as:

DESTINATION: Course section between nodes, e.g. 35 and 43. Distance travelled from initial node (35), equal to 165 m (for example).

(g) Special destinations

The present method serves, apart from the routing from a

particular starting point to a given arrival point, the routing to a destination that fulfils certain purposes such as:

- Professional
- Educational, Informative
- Recreational
- Touristic
- Emergency handling etc.

Indicatively, following special destination are mentioned:

■ Destination: PHARMACY

The data processing system is required to retrieve the course that will guide the vehicle from its present position to the nearest pharmacy.

■ Destination: PETROL STATION (TEXACO)

The data processing system is required to determine the course that will guide the vehicle from its present position to the nearest gasoline station (e.g. TEXACO).

■ Destination: ARCHAEOLOGICAL MUSEUMS

The data processing system is required to determine the course that will guide the vehicle from its present position to the nearest Archaeological Museum, then to the next nearest museum, thereafter to a third museum etc.

■ Destination: A(10:15), B(11:30), C(12:15), D(13:40)

The data processing system is required to set the course that will guide the vehicle from its present position to the exact point A and particularly not to arrive later than 10:15 a.m.. Then to set the course from point A to point B, not to arrive later than 11:30, thereafter to point C etc.

The points A, B, C, d etc. are defined by one of the aforementioned methods. As soon as the destination is keyed-in, by one of the above methods, the data processing system should be aware of the vehicle's departure position that is its present position. The exact vehicle's position is defined by one of the methods stated in Chapter d - Par. 36 and briefly given herebelow:

* Automatically, by the highly protected memory unit.
* By registration in the memory unit.
* By reception of signal transmitted from a transmitter or transmitters, in conjunction with or without the odometer.
* By using the odometer and the wheel transversal angle sensor.

etc.

The next data, which are required by the data processing system in order to set the course, are the specifications which the course sections have to comply with, so that they coincide with driver's requirements. The options of courses are indefinite and they are almost referred to every course characteristic that is registered in the microcomputer's memory unit e.g. the driver may request from the system to set the course in such a way so that the road surface transversal slope does not exceed, at any point, a certain value or the curvature radius does not exceed a certain limit.

Apart from these special specifications, there exist three specifications that the driver specifies and which mainly concern general targets to be reached by the course selection. These targets are:

■ MOST EXPEDITIOUS COURSE: The microcomputer is requested to set the course to be followed by the vehicle in order to arrive at its destination according to the criterion of the most expeditious drive duration.

■ MOST FUEL SAVING COURSE: The microcomputer is requested to set the course to be followed by the vehicle in order to assure the less possible fuel consumption.

■ SHORTEST COURSE.

Other more specific requirements for the course selection are:

■ MOST COMFORTABLE, where the lack of difficult and continuous manoeuvres is required.

■ SAFE, where the lack of dangerous locations, crossroads etc. along the route is required.

16. Routing Subroutines

The estimation methods for the course to be followed by the vehicle on two occasions, will be examined:

(a) When both the origin and destination points are defined.
(b) When the destinations are special ones (they will be analysed in other chapters).

More particularly:

(a) Defined origin and destination points

In order to set the course, the microcomputer utilises the following data:

(1) Departure point defined as

* Course section between two nodes e.g. nodes 43 and 58.

* Distance travelled from an initial node, e.g. 150m from node 43.

(2) Destination point defined as

* Course section between two nodes e.g. nodes 115 and 234.
* Distance travelled from an initial node, e.g. 235m from the initial node 115.

(3) Course specifications: e.g. EXPEDITIOUS COURSE

(4) Type, dimensions, weight and other particulars of the vehicle.

(5) Driver's personal particulars e.g. NEW, EXPERIENCED, TIRED, etc.

(6) Real time.

(7) Road network data, registered in the memory unit.

On the basis of the above data, the route is selected, in one first embodiment, as follows:

From the registration of the topology data in levels, (Chapter c - Par. 21), the levels which belong to the origin and destination points are identified. There are two cases:

<u>Case a</u>:

The origin and destination points belong to the same level, i.e. Suburban or urban networks.

<u>Case b</u>:

The origin and destination points belong to different levels, i.e. the departure point belong to the suburban network whilst the destination point belongs to the interurban network.

The method of route determination is the following:

Case a: Origin and destination points in the same type of level.

Subcase 1 - The two points belong to the same sector of the level (Figure 42) and to the same suburban network.

Let 1 be the origin and 2 the destination point. The courses that fulfil the driving specifications are selected around points 1 and 2. Let 1a-1b-1c and 2a-2b-2c be those courses. The courses fulfilling the driving specifications are selected at the ends of those courses. The courses around one of those points (departure or destination) ending at the same point, are rejected (and marked with an interrupted line). From the new points, the new courses that fulfil the specifications and move away from the origin and destination points, are estimated, whilst the courses, separately branching off the origin and destination point and ending at the same node, are rejected. The procedure continues in order to find a course that starts from the branches of the departure and a course that branches off the destination point, both ending or meeting at a common node.

From the common node, by following the reverse course towards the origin and destination nodes, the sequence of code numbers of the crossroads to be followed is estimated. The reverse course, from the common node, is strictly defined and ends at the destination and origin, since the branch sections ending at the same code number are exempted as aforementioned. Thus, during the reverse course, it is impossible that two course sections end from one node. Figure (42) shows such a procedure. The algorithm that estimates the route is shown on Figure (43). The description of this algorithm is the following:

The driving specifications and the departure and destination points, marked as nodes A and B, consist the data. The two

nodes, separately, are set to be entrances to the subroutine that edits from the database the adjacent nodes according to the topology registration of the road network data (chapter b - Par. 9).

Let $[X_1]$, $[X_2]$, $[X_3]$, $[X_4]$ be the adjacent nodes of the departure point A and $[Y_1]$, $[Y_2]$, $[Y_3]$, $[Y_4]$ the adjacent nodes of the destination point B. These two data are checked for possibly identical code numbers and re-entered as data in the subroutine of route control. In the same subrouting the origin and destination points are entered. The courses $[A \to X_1]$, $[A \to X_2]$, $[A \to X_3]$ etc. as well as the courses $[Y_1 \to B]$, $[Y_2 \to B]$, $[Y_3 \to B]$ etc. are checked to ascertain if they comply with the specifications initially set. If they do comply with the specifications, those routes are saved and the nodes $[X_1]$, $[X_2]$... and $[Y_1]$, $[Y_2]$ etc. are temporarily saved. If they do not comply with the specifications, the routes and the corresponding nodes are rejected. The finally selected nodes $[X_1]$, $[X_2]$ etc. and $[Y_1]$, $[Y_2]$ etc. are checked to ascertain if there exists a common node, in which case the route starts from point A to the common node and thereafter to point B. In the contrary, nodes $[X_1]$, $[X_2]$ etc. and $[Y_1]$, $[Y_2]$ etc. are re-entered in the subroutine of determination, through the database, of the adjacent nodes.

The said adjacent nodes are checked for concurrence, e.g. an adjacent node of $[X_2]$ concurs with the adjacent node of $[X_3]$ being the node $[Z_{45}]$, for example. In this case one of the routes, that is $[X_2 \to Z_{45}]$ or $[X_3 \to Z_{45}]$, is rejected. The rejection criterion is the following control. In this control, one of the routes has to be rejected. Thereafter, the new node sequence is entered into the control position along with the previous routes which are saved. In this position it is controlled whether the total routes from an origin at the first node sequence and from the first node sequence to the second one, fulfil the specifications set. Likewise, the routes from the second node sequence to the

first one and thereafter to the destination point are examined. Each route which does not fulfil the specifications is rejected. Also, one of the routes guiding to the same point is rejected. The new total routes accepted are saved and the second node sequence from the origin and destination point is examined. If certain points concur, then the route to be followed by the vehicle, is set to be the total route from a departure node towards the common node and thereafter the total route towards the destination node. In case of non-concurrence, the said second node sequence is re-entered into the subroutine of adjacent nodes estimation in order to find the total routes upto the third node sequence and the soforth. The procedure is repeated upto the estimation of a common node of the branch that starts from the origin and the branch that ends at the destination.

Subcase 2: Figure (44) shows the algorithm of route estimation in case of different and distant origin and destination point. The origin [Σ_1], the destination point [Σ_2] and the route specifications [expeditious, ecomonical, comfortable] are entered as data. The procedure within the interrupted line is repeated separately for the origin and the destination point. This procedure is the following:

For the origin [Σ_1] and the destination point [Σ_2], the corresponding adjacent nodes are estimated with respect to the level they belong to [e.g. if the two points belong to the suburban network, the adjacent nodes refer to the data level of the suburban network]. If the said points belong to different levels, the procedure is followed upto the point of the lower level [e.g. if the origin belongs to the urban network whilst the departure point belongs to the interurban network, the procedure which falls within the interrupted line is only followed for the destination point]. This procedure is identical to the procedure shown in the previous figure with the view to estimate successive node generations with total routes that fulfil the specifications

set. Each node and route generation, separately, which starts - on the one hand - from the origin and - on the other hand - ends at the destination point, is controlled in order to ascertain whether a node from the origin or destination point belongs at the same time to a road network of higher level.

Case b: Origin and Destination point in another type of level.

In case that one of those points, either of destination or of origin, belongs to a higher level, the procedure is followed only for the lower level node until a node of the same level, with another node (origin and destination), is found. If nodes of higher levels are found simultaneously, the routes ending at those higher level nodes are only saved in the memory unit and solely the said nodes follow the procedure within the interrupted line. At the same time, the procedure is fed from the database of the said higher level. The procedures are repeated until a common node is found, where the route ends from the origin and/or ends, through a course, at the destination point.

In order to abide by the specifications of routes selected by the microcomputer, the latter takes into consideration the road network data that influences the movement of the particular vehicle and driver. An example of data which are taken into consideration by the microcomputer for selection of MORE EXPEDITIOUS ROUTE for an unexperienced driver of a small private car, is given herebelow:

<u>Routes fulfilling the specifications of speedy driving, i.e.:</u>

- Many lanes
- Priority routes
- Routes with a small number of traffic lights
- Small number of turns

- Shorter, lengthwise, route

An example of data for:

* EXPEDITIOUS ROUTE
* INEXPERIENCED DRIVER
* LARGE VEHICLE

Routes that fulfil the specifications are:

- Large road surface curving radii
- Small road surface slopes
- Small number of turns
- Small number of traffic lights
- Routes allowing circulation of large vehicles
- Roads with small traffic congestion

In practice, the microcomputer possesses the complete image of the road network and is in a position to predetermine the course of the vehicle, at any moment. Therefore, it controls from the beginning the course and concludes whether the latter falls within the specifications set. For the most expeditious estimation of QUICKER ROUTE, the microcomputer takes into consideration the ACCESSIBILITY DEGREE (Chapter b - Par. 7). An example of estimating the quicker route, by the use of the accessibility degree, is given herebelow:

$$\frac{\text{LEGTH OF ROUTE}}{\text{ACCESSIBILITY DEGREE}}$$

Let two courses be compared:

1st course

Nodes: 35 ——> 47 ——> 34 ——> 68

Accessibility degree: 35 ——> 47 : 5 length 300m
94 ——> 34 : 8 length 200m
34 ——> 68 : 9 length 100m

Total number of course speed:

$$\frac{300}{5} + \frac{200}{8} + \frac{100}{9} = 96.11$$

1st course = 96.11

<u>2nd course</u>

Nodes: 35 ——> 94 ——> 49 ——> 68

Accessibility degree: 35 ——> 94 : 7 length 200m
94 ——> 49 : 8 length 300m
49 ——> 68 :10 length 50m

Total number of course speed:

$$\frac{200}{7} + \frac{300}{8} + \frac{50}{10} = 71.07$$

2nd course = 71.07

The 1st course is therefore selected.

17. <u>Multiple Course Selection</u>

The present method provides the following additional functions for the routing:

(1) Selection, apart from one course which fulfils the criteria set, of a small number of courses being adjacent to the main one, from the suitability point of view. For each one of the other courses, it is given a percentage of the course which is common with the first one, e.g. number of common nodes. This is achieved during the course estimation procedure by withholding more than one common points (nodes) of departure branches or towards the destination. One new course is selected on every common point.

(2) Selection of "random" courses. During the course

estimation procedure [Figures (43 and (44)], the data processing system does not check whether the total course fulfils certain specifications. On the said check point, it is merely selected a "random" code among each generation of codes (e.g. the first one registered in the memory unit) or "random" codes (e.g. each time, the first three one). Thus, "random" courses with no essential specifications are selected.

18. Routing towards the Nearest Location

In order to meet the requirements of special destinations, the method provides selection of course from the vehicle's present position to the nearest location of the same group, e.g. nearest pharmacy or gasoline station. This supporting service is provided as follows:

The driver simply keys-in the code number of the location he/she wants to be guided to, e.g. PHARM for pharmacy. The processing system considers that the MOST EXPEDITIOUS COURSE is the specification set for the selected course, in case that the driver does not predetermine the type of course. The data processing system uses a part of the algorithm described in Figure (43) and considers as data in the memory unit the ones referring to areas and building at both sides of the road network (Chapter b - Par. 13). This algorithm is repeated for this special service in Figure (45). According to this algorithm, the adjacent nodes from the origin are found as well as the course sections between origin and first sequence of nodes are examined in order to locate a pharmacy, for example. In case that no pharmacy is located, the adjacent nodes of the first sequence are found and the course sections are examined in order to locate a pharmacy and the soforth. This procedure is repeated until a course section, including a pharmacy is found.

As aforementioned, the time limits of time varying elements that refer to the road network, are placed in a special

position in the database. Thus, in the above service, the microcomputer estimates the course towards the nearest area e.g. pharmacy, gasoline station, garage etc. and in addition it checks the memory unit data in order to verify whether the particular area is working during the time of course selection (e.g. from the pharmacies it selects the ones open at night-time, if registered in the memory unit, and sets the course. The same applies for the Petrol Stations or the shopping centres).

19. Routing with Programmed Stops

It refers to a continuous course selection, that covers all points of the same group among a general selection (e.g. a course that passes by the Archaeological Museums). The processing system, in this embodiment, accepts the vehicle location and the general description of the areas of the same group, towards which the vehicle is directed (e.g. MUSEUMS), as data. Among the data registered in the memory unit concerning areas or building at both sides of the road network (chapter b - Par. 13), the processing system "edits" the position codes of these areas, that is nodes of entrance into and exit from the course section where the areas are located at, as well as the exact travelled distance between the entrance node and the destination. Thereafter, by using an algorithm identical to the one of the location estimation of the nearest building, mentioned before in Chapter b. - Par. (18), the processing system estimates and sets the course towards the nearest area of the same group. Finally, from this area it sets the course to the second nearest one and the soforth.

Note: As nearest area we signify the nearest from a course length point of view and not from an absolute geometric distance point of view. It is understood that the driver is capable of predetermining the sequence of areas he/she wants to visit, if desired, in which case a simple course estimation algorithm is used, as mentioned in chapter c -

Par. (16).

20. General Advantages of Routing

The characteristics of the services provided in this section of course estimation, which consist the advantages of the method, are the following:

(a) The estimation of courses from one point to another is very fast, as it merely uses the road network topology elements as data (that is, adjacent nodes of each node) and not absolute or cartesian coordinates of the nodes.

(b) On the basis of the complete topology and topography elements, as well as the traffic signs of the road network, the microcomputer predetermines all the course details from the origin. It is, therefore, in a position to predetermine whether the course accurately fulfils the specifications set.

(c) The use of the accessibility degree applying on the particular vehicle and the particular driver, allows the quickest estimation of course duration.

(d) The road network data are examined in connection with the particular vehicle or driver, allowing thus the support of the driver and not of the eventual system user.

(e) Finally, the special services provided to the drivers serve a plethora of practical needs encountered in the daily use of a vehicle, and in addition they serve the use of the vehicle as a supporting means for professional, touristic, recreational and other purposes.

Among the examined state-of-the-art system, there is none that provides such supporting services and particularly in an extent to serve the particular driver of the particular vehicle. A characteristic of the supporting services use for

professional reasons, is their application in TAXIS (Chapter c. - Par. 22).

21. Arrangement of Road Network Topography Elements (5 levels)

It has been stated that the road network topology representation is provided to serve the driver's real needs. The arrangement of the road network topographic elements, that is the evaluation of the topological data, serves the practice of tracing and constructing the road network. The road network has been constructed to serve the movement of vehicles:

* from state to state of a wider area e.g. a continent (Interstate road network)
* from city to city of a particular state (Interurban road network)
* from region to region of a city (Urban road network)
* outside the quarter of each region (Quarter road network)

The arrangement of the topology data of a road network serves the arrangement of the road network of a wider area. More specifically, the said arrangement is as follows:

The code number of the road network nodes are arranged in "levels", each "level" corresponding to one of the aforementioned road networks. Thus, in the first level, the code numbers of nodes and their connection referring to the interstate network are registered. In the second level, the nodes and their connection referring to the interurban network are registered, in the third level the urban network is registered and the so forth. Sections of the arterial roads that simultaneously belong to two levels (e.g. sections of an interurban network passing through cities and also consist a section of the urban network) are registered in both levels. An example of the topological representation of the road network in two levels is shown in Figure (46).

In Figure (46), the real image of the connection of two regions of a city with the urban network is shown. In the first level, only the urban network with nodes A1, A2, A3, A4, A5, A6 and their connections appear. In the next level, only the topology of the road networks of the regions with nodes 1, 2, 3, 4, 5 etc appear. Table (6), hereinattached, presents the contents of each level.

The characteristics of this topography data arrangement are the following:

(a) As a result of the arrangement of the road network topological data, the function of the data processing system is significantly facilitated. For every movement of the driver, the processing system does not have to search in all available data and select the information required for a particular course, but instead it refers to the level which concerns each course section. An example of such a facilitation in the processing system's operation is the following:

In order to set the course from a neighbourhood in a city (1) to a neighbourhood in another city (2) of another state, the processing system refers to the below mentioned levels:

LEVEL E (Neighbourhood network) of the city (1)
LEVEL D (Suburban network) of the city (1)
LEVEL C (Urban network) of the city (1)
LEVEL B (Interurban network) of the country of a city (1)
LEVEL A (Interstate network)
LEVEL B (Interurban network) of the country of a city (2)
LEVEL C (Urban network) of the city (2)
LEVEL D (Suburban network) of the city (2)
LEVEL E (Neighbourhood network) of the city (2)

(b) The software that covers the course, appears to be simplified since the same procedure is followed on every level. Thus, if the software that concerns movement in one

LEVEL A	INTERSTATE NETWORK
	It includes code Nrs. of arterial road nodes leading from country to country
LEVEL B	INTERURBAN NETWORK
	It includes code Nrs. of arterial road nodes leading to cities outside the state
LEVEL C	URBAN NETWORK
	It includes code Nrs. of nodes that connect neighbourhoods of a district
LEVEL D	SUBURBAN NETWORK
	It includes code Nrs. of nodes of each neighbourhood

TABLE (6) - ARRANGEMENT OF ROAD NETWORK TOPOLOGY

of those levels e.g. level E, is developed, then the same software is used for the next level D and so forth. Eventually, the only change is the database that the software addresses to. A saving in software is therefore indirectly achieved, which is available for additional supporting functions, provided by the method.

(c) The method of data arrangement indicates, in the most reasonable way, the possible registration of data in more memory units (e.g. diskettes). Figure (47) presents the possible registration of the road network data of the European Continent.

* For LEVEL A, a uniform memory unit, that includes the international European network, is provided.
* For LEVEL B, a number of diskettes, that covers the interurban European country network, is provided. This number is not necessarily identical to the number of countries.
* For LEVEL C, a number of memory units (diskettes), that covers the urban network of the cities of European countries is provided and so forth.

It is understood that, depending on the volume of information that can be stored in each memory unit, it is possible to have information of various levels or urban networks of more than one cities, for example, registered in the same memory unit.

(d) The commercial impact of such a data arrangement is obvious. The prospective user of the system has the option to select the memory units that mostly serve his/her movements. The data registration of other systems, which have been studied, covers very wide areas which simply overlap. Thus, the driver has to be provided with all information concerning the continent in order to drive from one terminal point to another. The present method covers the needs of a driver, provided he/she has been supplied with

only the necessary memory units, that may cover for example:

* the neighbourhood of departure or destination
* the suburban network of the districts of departure and destination
* the urban network of the cities of departure and destination
* the interurban network of the countries of departure and destination
* the interstate network of the continent

Moreover, the method provides the option to register in a memory unit (diskette) only the information that concerns a particular course as selected from the whole available information. This is feasible with the present method, unlike with the state-of-the-art systems, which have been studied.

(e) The arrangement of the topographic data in levels facilitates the data arrangement which concern other supporting functions provided to the driver. Thus, different supporting functions are required for driving within an interstate network, where high speeds are developed, traffic signs exist rarely and the driver faces problems of boredom and fatigue, or different supporting functions are required for driving through an interurban network with frequent traffic signs, frequent stops and pedestrian crossings and crossroads, where the drive has to be alert and extremely careful. Therefore, different supporting data are registered in different levels, which are used for the various supporting functions.

22. Taximeter - Routing for Taxis

It concerns a service for course estimation and evaluation, applied on taxis for the transportation of clients from the vehicle's position, at the time of boarding, to a destination.

The client has the following options:

(a) To key-in the destination, by following one of the methods stated in Chapter c - Par. (15). The processing system estimates the shortest course that corresponds to the minimum cost.

(b) To predetermine a course section, that he/she desires to be followed by the vehicle, e.g.
   * street sections he/she desires to transit
   * initial course section
   * final course section

(c) To predetermine a group of destinations, the nearest of which he/she desires to be driven to (e.g. pharmacies).

(d) To predetermine a sequence of points, he/she wants to be stopped to.

(e) To make other choices that cover functions of course estimation, as mentioned before.

On the other hand,the taxi driver has the following options:

(a) The method allows the estimated cost of the course to be calculated on the basis of other than the travelled distance, as presently occurs. Therefore, the cost may be calculated on the basis of the total time required or the difficulty of manoeuvres involved during the course or to depend on the stops and turns encountered.

(b) The cost of the course may be calculated at the beginning of the trip. The passenger is then informed at the beginning about the fare involved.

(c) The driver may request passage from a point outside the course, charging the client the cost of the shortest course initially agreed upon (e.g. passage through areas ideal for hiring the taxi).

(d) Finally, each course is registered in the registration unit and is used as a directory for professional use,

e.g. statistics, tax purposes etc.

Such a use of the supporting service is expected to completely differentiate the taxi hire. The general structure of the algorithm which embodies these services is given in Figure (48). In this Figure, the vehicle present location is shown to be input as data in the route estimation algorithms and, in addition, it is used as a comparison to verify if the vehicle position falls into the correct route. Other data is the type of route with a specific reason of selection by the processing system, in order to achieve SHORTEST ROUTE and options for ECONOMICAL, SHORT, SAFE and other routes. Options concerning the destination are the DATA OF EXACT DESTINATION, DESTINATIONS OF THE SAME GROUP (e.g. PHARMACIES, PETROL STATIONS) for selecting the shortest course or intermediary courses, as stated in Chapter c - Par. (17) and (19). The eventual algorithms are fed with the road network data of the memory unit. A route registration unit is also provided by the method.

23. Regulation of Traffic (travelling code)

The microcomputer is aware of any position of the vehicle, whatsoever, with accuracy, as each node is registered in the database with a unique number. Also, its connection to other nodes and the exact distance between nodes are known. The microcomputer has registered in its memory unit the node that the vehicle passed through and is aware of the destination node as a result of the routing. Let the vehicle be directed to the node 200 originating from the node 365 and let the distance in-between be 132m. When the microcomputer starts counting the distance from 365 to 200, bears in mind the said distance of 132m and counts by deducting each meter travelled by the odometer. Let the vehicle be located at 7m before its destination, that is before node 200. The microcomputer has registered the 365, 7

and its destination 365-7-200. Point 7 is unique in this course from 365 to 200. This point from 200 to 365 is 200-125 (which is 132-7) and 365 (or 200-125-365). This number is therefore located at the same street level but at the opposite lane. It is concluded, therefore, that for each point of the street, corresponds only one unique number among the map that describes it.

Every vehicle in motion, possesses such a code number (travelling code) which is continuously varying depending on the vehicle position. The same code number cannot be possessed at the same time by another vehicle, except for the case that the second vehicle moves towards the same direction but at the lane of the same street. In case the lanes are registered in the database, then again the travelling code number is unique for each vehicle and only the vehicles, passing through the said point, successively possess the same code number. Therefore, the millions of vehicles circulating at the same time, possess different code numbers at each instant. Consequently, the reception of a message which needs a code identification, may be accomplished only by the vehicle that possesses the code at the particular moment.

Other preconditions that enable message reception are:

(a) If the message addresses to vehicles in possession of the code number 365 to 200 in general, as in above example, then all vehicles moving from 365 to 200 obtain this attribute.

(b) The same may occur in case of vehicles moving in a particular area. The message may be received by every such vehicle.

(c) The vehicles that aim at arriving to a specific destination through the specified routing.

(d) Same as above, when the vehicles are to pass through a particular point.

(e) Vehicles with licence plate number registered in the

memory unit. Thus, only the particular vehicles may receive the message.

Application of the travelling code number on the traffic problem solution

In order to accomplish the above tasks, the system is supported by a travelling code number, in four different ways that include ten different methods, in total, for the regulation and avoidance of traffic congestion.

Methods of warning

TRAFFIC POLICE: Four methods originate from the action of the Traffic Police.
MICROCOMPUTER: Two methods originate from the instructions given by the vehicle microcomputer which depend on the traffic flow.
DRIVER: Three methods originate from the judgement of the driver which is supported by the microcomputer and may change the course (deducting a street section, entering into the alley-ways, deducting the whole course etc.).
INITIAL NAVIGATION: One method originates from the initial scheduling of the course.

Ways of warning

TRAFFIC POLICE

(1) The central traffic police station, depending on the traffic conditions, transmits encoded messages that include commands or recommendations for course changing, warnings, individual calls etc. Those messages are transmitted by the traffic police to all vehicles, in groups or individually.
(2) Traffic police local stations which are activated, at will, by the central station.
(3) Portable transmitters which are installed on main street points and may be removed.

(4) Portable transmitters which are used by traffic policemen and transmit the message to the adjacent vehicles.

VEHICLE MICROCOMPUTER

(5) Messages which are stored in the memory unit and concern the rush hours, special transit times, repeated accumulations e.g. in football fields.

(6) The microcomputer's autonomous "judgement" conceives that the odometer counts few pulses in relation to the street, which means traffic congestion and therefore it selects a new route.

DRIVER

(7) Depending on the driver's judgement, he/she realises the traffic congestion and requests from the microcomputer to exclude 5 or 10 consecutive crossroads and to reroute.

(8) Depending on the driver's judgement, he/she requests from the microcomputer to cancel the whole initially selected route and to recommend a completely new one.

(9) By deviating, at driver's will, the vehicle turns to adjacent street and a new route is automatically selected.

INITIAL NAVIGATION

(10) The automatic selection of the most appropriate route.

<u>IN DETAIL</u>

<u>TRAFFIC POLICE - 1ST METHOD</u>

In one embodiment, the traffic police transmits from the station code numbers that the in-vehicle microcomputer receives through a receiver. Thereafter, the encoded messages are decoded by the microcomputer and are divided as follows:

(a) GENERAL TRAFFIC POLICE CODE NUMBER (uniform) that is

translated from the microcomputer as "take into consideration the traffic police instructions". This general code number is the key that opens the way for the microcomputer to accept the instructions or the information.

(b) AREA CODE NUMBER, that is the general code number representing all the other ones of a particular area. By its transmission, only the microcomputers of the vehicles moving in the particular area are activated.

(c) NODE CODE NUMBER, which is the code number of the crossroads. When two adjacent node codes are transmitted, the vehicles moving between those two nodes are activated. The section in-between, may be the part of a street between two blocks.

(d) CODE NUMBER OF TOPOGRAPHIC LOCATIONS for a determined distance. This code number represents any street location measured in meters or centimeters (depending on the measurements of each vehicle's odometer) away from the crossroad. It is understood that this code number is always the same for the same locations of every street.

The above code numbers (a to d) only determine the vehicles that may receive and decode the message depending on their topographic location, whilst the code numbers, herebelow, only transmit the two kinds of messages, being:

(e) CODE NUMBERS FOR PREPARATION OF COURSE CHANGE. In this way, the microcomputer may accept cancellation of the route initially selected (cancellation of the routing code number) and preparation to accept a rerouting or recommendation for free selection of the new route.

(f) CODE NUMBERS OF THE NEW COURSE INDICATED. These are all the nodes of the course indicated or, depending on the software, they are only few dominating nodes of the course indicated.

(g) CODE NUMBERS THAT ENFORCE AUTONOMOUS RE-ROUTING. These codes assist as long as only each microcomputer is aware of the destination and may achieve a correct re-routing for the respective vehicle.

(h) CODE NUMBERS BEING AUTOMATICALLY DECODED AND CAUSE VOCAL MESSAGE TRANSMISSION. These codes are immediately decoded at the moment they are received. Thus, the driver may hear the transmitted information which was selected and is permanently stored in the microcomputer's memory unit.

(i) CODE NUMBER OF INDIVIDUAL WARNING. If the vehicle code number (licence plate number) is transmitted after the general code number of the traffic police, the latter may have immediate access and communicate with particular drivers in case of emergency. Therefore, there exist individual warnings to a particular driver when the vehicle's licence plate number is used, and individual warnings to any drivers may pass from a particular road section or a certain point. Likewise, an individual warning may be transmitted to a particular vehicle e.g. a doctor's vehicle, when it approaches or passes from a certain location. That means that the call is stored in the memory unit of the microcomputer and is decoded only when the vehicle obtains the respective real-time code.

(j) CODE NUMBERS STORED IN THE MEMORY UNIT FOR A LONG PERIOD. It is impossible for each event that requires warning, either for a short time or constantly for many months, to continuously transmit the respective code. For this reason, the code numbers warning on every event, when transmitted once, are received by all vehicles and stored for as long as the traffic police feels necessary. When the traffic police decides that they are no longer needed, may cancel the first message or give a new one stronger than the latter, by the appropriate code transmission. This message may not be decoded unless the distance (in meters) of the vehicle at the exact position, where the warning should be

transmitted, appears on the microcomputer. Thus, the warning it is vocally transmitted to those who happen to pass from a hazardous area as many times as the transits. Also, upon receipt of a driver's or traffic policeman's call of warning on a hazardous obstacle on the road, the relevant message may quickly reach the drivers moving to or approaching at the particular area. New one-way streets, new traffic lights etc. are stored in the memory unit for a long period and are decoded every time the vehicle reaches the respective topographic location.

The above code numbers are used as follows:

1) In order to avoid traffic congestion or to transmit necessary warnings, the traffic police selects the area of required transmission as well as the vehicles that they desire to receive it. Thereafter, they transmit the relevant code numbers as specified hereinabove. In this way, the traffic police provides the desired vehicles with the new route to be followed.

2) The traffic police may direct other vehicles to the right, others to the left and allow other to remain on course, according to their instructions. Therefore, for the same location of traffic congestion, the traffic police may provide different instructions to the vehicles passing by.

3) Whereas the vehicles drive towards one direction coming either from the right, or left or centre, and whereas the code numbers of the areas, where the vehicles come from are known, the traffic police may instruct different courses for the vehicles coming from different areas.

4) Certain messages is possible to be locally transmitted to the vehicles that move at a particular road between two crossroads or two street points. Also, it is possible to transmit a message to certain vehicles e.g. passing from a specified street point with one meter accuracy or even ten

centimeters. This is achieved since every vehicle passing from the specified topographic point, gains possession of the specified accuracy code for a short time period.

5) Also, it is possible to have calls in groups e.g. by one code the police patrol vehicles may be gathered at a specific location. The quick route estimation renders the police team flexible. The same may apply on doctors or other professionals.

6) By the code transmission (vehicle licence plate number), the individual warnings are facilitated and thus messages are transmitted only to vehicles concerned and not to thousands of other vehicles.

7) Finally, messages and information concerning the road condition (water or ice on the road), traffic lights operation etc. are transmitted.

<u>TRAFFIC POLICE - 2ND METHOD</u>

<u>Receivers and Transmitters</u>

In a second embodiment, dozens of transmitters and receivers of low range (500 or 1000 meters) are installed in every central location and major crossroad. The traffic police instead of transmitting local messages for dozens or thousands of cases, activates those transmitters and receivers which transmit the relevant local messages, instead of the central station. Thus, the main transmitter is not overloaded but it is only activated by the central station which also determines the duration of transmission and at the scheduled time its operation is interrupted. Those messages may be more than one for different vehicles and/or more messages for the same vehicles. The said transmitters and receivers may transmit every kind of code as in the case of main transmitters. Therefore, depending on the existing needs, a number of 10, 500 or 1000 transmitters

and receivers may be activated.

TRAFFIC POLICE - 3RD METHOD

Transportable Transmitters

In a third embodiment, transportable transmitters of low range are installed, in the same way as the portable traffic signs, in central emergency locations. They may be tuned by the traffic policemen who install them in order to transmit the necessary codes, in case of an event. Their function may be interrupted by means of a timer. Particularly for the change of course due to works ahead, the transmitters may function for an extensive period providing more alternatives than the traffic regulatory signs.

TRAFFIC POLICE -4TH METHOD

Portable Transmitters

In a fourth embodiment, transmitters carried by traffic policemen either in their vehicles or while they walk, may transmit, at low range, all the signals described in the above three embodiments. Thus, the traffic policeman having an immediate visual impression of the traffic situation may effectively intervene. The traffic policeman may also carry a receiver in order to receive the general information from the central system.

IN-VEHICLE MICROCOMPUTER - 5TH METHOD

During programming for the evaluation of roads concerning their extent of accessibility by the vehicles, various factors are taken into consideration, which have been stored in the memory unit, such as:

1) Change of traffic conditions depending on the time zone,
2) Prohibition of access during certain hours,

3) Repeated traffic congestion during certain days and hours near sports fields, theatres etc.,
4) Seasonal tourist flow,
5) Traffic congestion during weekends,

etc.

In this way, the microcomputer is assisted in selecting the best possible course.

IN-VEHICLE MICROCOMPUTER - 6TH METHOD

The microcomputer may "elect" that there exists a traffic congestion or an accident on the road where, for example, under normal conditions the vehicle's speed should be e.g. 60 Km/hour, whilst that particular moment the speed is 10 Km/hour. If the vehicle proceeds for example 200 meters and nothing is changed, the driver may select a new course. This is useful when the driver does not know whether at the particular location the traffic is always congested, and this may happen in case the driver is unfamiliar with the region. If for example the traffic is usually congested at a particular location and time, the vehicle's microcomputer is aware of that and selects a new course.

DRIVER - 7TH METHOD

When the driver elects that he/she should deviate from the area where the traffic is congested, he/she requests the microcomputer to delete from the scheduled course 5 or 10 consecutive crossroads. Thus, the microcomputer selects a new course without including the said crossroads. The number of crossroads is input by the driver by estimating, in his/her view, how many suffice to deviate the traffic congestion.

DRIVER - 8TH METHOD

When the driver elects that he/she should change the whole

course, he/she may request the microcomputer to estimate a completely different course excluding the crossroads of the initial one.

DRIVER - 9TH METHOD

When the driver changes the course to the left or to the right of the road initially followed, new courses are automatically selected. Naturally, he/she should estimate the extent of deviation in order to avoid the initial course.

INITIAL NAVIGATION - 10TH METHOD

The initial navigation indirectly but sufficiently assists in avoiding traffic problems:

1) The vehicle data processing system selects, based on real data new courses, while the drivers drive through known roads where traffic congestion occurs.
2) The possibilities of selecting QUICK-ECONOMICAL-SHORT routes, increase the use of more roads.
3) The minimisation of traffic violations and the prevention of accidents are achieved.
4) Saving time, otherwise lost in driver's continuous efforts to find the route or in continuous stops to ask the others, is achieved.

d. NAVIGATION

24. Vehicle's Position Estimation

The vehicle's position estimation is accomplished by using the measurements of travelled distance and transversal angle of directional wheels. Figure (36) shows the measurement mainly accomplished by the measurement of the wheels transversal angle. In Figure (36) it is shown that from the directional wheels transversal angle measurement, the

curvature radius and the centre of vehicle's course are immediately derived. If for a time period ΔT the wheel angle is not altered, the vehicle will make a circular course around the estimated turning centre and with the estimated curvature radius. Figure (49) shows the new vehicle position for the course l_1 and l_2 with course curvature radii ρ_1 and ρ_2. The vehicle's initial position and direction as well as the readings of travelled distance measuring and directional wheels transversal angle, consist the problem data.

Let it be [Figure (49)]:

X_0, Y_0	= initial cartesian coordinates of the vehicle
φ_0	= initial angle between axis OX and vehicle's direction
ρ_1 & l_1	= curvature radius (from a steering wheel angle of turn) for travelled distance l_1
ρ_2 & l_2	= curvature radius (from a steering wheel angle of turn) for travelled distance l_2
X_1, Y_1, φ_1	= coordinates and direction angle of a vehicle at position 1
X_2, Y_2, φ_2	= coordinates and direction angle of a vehicle at position 2

From Figure (49) it is derived that:

$$\omega_1 = \frac{l_1}{\rho_1} \qquad \omega_2 = \frac{l_2}{\rho_2}$$

$$\varphi_1 = \varphi_0 - \frac{l_1}{\rho_1} \qquad \varphi_2 = \varphi_1 - \frac{l_2}{\rho_2}$$

General type $\varphi_1 = \varphi_0 - \frac{l_1}{\rho_1} \longrightarrow$

$$\boxed{\varphi_1 = \varphi_0 - \frac{l_1}{M.\cot.\theta_1 - \frac{S}{2}}}$$

φ_0 = initial direction angle
φ_1 = final direction angle
I = travelled distance
θ_1 = turning angle of transversal wheel level
M = wheel base
S = track rear

Estimation of the coordinates x_1, y_1 & x_2, y_2 is done through the formulas:

$$X_{\varkappa 1} = X_0 + \rho_1.\cos(90 - \varphi_0) = X_0 + \rho_1.\sin\varphi_0$$
$$X_1 = X_{\varkappa 1} + \rho_1.\sin\beta_1 = X_{\varkappa 1} + \rho_1.\sin(\omega_1 + 90 - \varphi_0 - 90)$$
$$X_1 = [X_0 + \rho_1.\sin\varphi_0] + \rho_1.\sin\left(\frac{l_1}{\rho_1} - \varphi_0\right)$$

$$Y_1 = Y_0 - \rho_1.\cos\varphi_0$$
$$Y_1 = Y_{\varkappa 1} + \rho_1.\cos\beta_1 = Y_{\varkappa 1} + \rho_1.\cos(\omega_1 - \varphi_0)$$
$$Y_1 = (Y_0 - \rho_1.\cos\varphi_0) + \rho_1.\cos\left(\frac{l_1}{\rho_1} - \varphi_0\right)$$

Therefore, the general formulas for estimating the coordinates are:

$$\rho_1 = M.\cot\theta_1 - \frac{S}{2}$$

X_0, Y_0, φ_0 = initial coordinates and vehicle's turning angle
ρ_1 = curvature radius

M = wheel base

S = track rear

θ_1 = vehicle's directional wheels transversal angle

$$\varphi_1 = \varphi_0 - \frac{l_1}{\rho_1}$$

φ_1 = new vehicle's turning angle in radians

φ_0 = initial vehicle's turning angle in radians

l_1 = travelled distance

$$X_1 = [X_0 + \rho_1 \cdot \sin\varphi_0] + \rho_1 \cdot \sin\left(\frac{l_1}{\rho_1} - \varphi_0\right) =$$

$$X_0 + \rho_1 [\sin\varphi_0 - \sin\varphi_1]$$

$$Y_1 = [Y_0 + \rho_1 \cdot \cos\varphi_0] + \rho_1 \cdot \cos\left(\frac{l_1}{\rho_1} - \varphi_0\right) =$$

$$Y_0 - \rho_1 [\cos\varphi_0 - \cos\varphi_1]$$

$$\boxed{\begin{aligned} X_1 &= X_0 + \rho_1[\sin\varphi_0 - \sin\varphi_1] \\ Y_1 &= Y_0 + \rho_1[\cos\varphi_0 - \cos\varphi_1] \\ \varphi_1 &= \varphi_0 - \frac{l_1}{\rho_1} \end{aligned}}$$

The algorithm that estimates vehicle's position at any instant, operates as follows:

Data = X_0, Y_0, φ_0 (initial coordinates and vehicle's direction)

Δl, θ (distance travelled by the vehicle with transversal slope of wheels Θ)

M, S (wheel base and track rear)

For every travelled distance Δl the directional wheels angle is measured (considered to be constant when Δl very short) and the new vehicle's position and direction is estimated by

the initial formulas. The procedure is repeated for the next travelled distance Δl_1 with θ_1 as directional wheels turning angle and so forth.

Figure (50) presents the algorithm in a diagram.
If $\theta = 0$ then $\varphi_1 = \varphi_0$
$X_1 = X_0 + \Delta l.\cos \varphi_1$
$Y_1 = Y_0 + \Delta l.\sin \varphi_1$

25. Improved Position Estimation Method

The previous relations are correct and the measurements carried out estimate the precise vehicle's position provided that the directional wheels transversal angle remains constant for the travelled distance Δl. This is not achieved, however, in practice. In practice, the driver is continuously turning the steering wheel and continuously changes the directional wheels transversal angle, resulting in inaccuracy of the former formulas and insertion of error. Figure (51) shows the error in vehicle's position inserted when from position 1 to position 2 the driver is only changing the transversal angle twice, whilst in the broken line curve the driver changes the transversal angle four times. It is therefore necessary to examine equations that take into consideration the change of directional wheels transversal angle in order to estimate the vehicle's position.

In a first embodiment, we consider that during the distance Δl, the course curving $K=1/\rho$ changes in a linear way in conjunction with the travelled distance. This is described as follows:

For a travelled distance l from 0 to l_T, the curving changes linearly from K_0 to K_T that is:

$$K = K_0 + l * \frac{K_T - K_0}{l_T}$$

$$K = \frac{1}{\rho} = \frac{1}{M.cotan.\theta - \frac{S}{2}}$$

The vehicle's turning angle is described as follows:

$$d\varphi = d\theta = \frac{dl}{\rho} = K.dl$$

Integrating:

$$\int_{\varphi_0}^{\varphi_T} d\varphi = \varphi_T - \varphi_0 = \int_0^{l_T} K.dl = \int_0^{l_T} (K_0 + l * \frac{K_T - K_0}{l_T}) dl \rightarrow$$

$$\varphi_T = \varphi_0 + \frac{l_T}{2}(K_T + K_0)$$

$$\varphi_T = \varphi_0 + \frac{l_T}{2}\left(\frac{1}{\rho_T} + \frac{1}{\rho_0}\right)$$

The position estimation, in a first embodiment, is shown by the algorithm of Figure (52). In a second embodiment, the transversal angle of the directional wheels is considered to be linearly varying in connection to the travelled distance l, that is for a distance l from 0 to l_T.

θ is linearly varying from θ_0 to θ_T i.e.:

$$\theta = \theta_0 + l * \frac{\theta_T - \theta_0}{l_T}$$

The curvature radius is described as follows:

$$\rho = M.cotan\ \theta - \frac{S}{2}$$

$$\rho = M.cot\left[\theta_0 + l * \frac{\theta_T - \theta_0}{l_T}\right] - \frac{S}{2}$$

The vehicle's turning angle is described as follows:

$$d\varphi = d\theta = \frac{dl}{\rho}$$

Integrating:

$$\int_{\varphi_0}^{\varphi_T} d\varphi = \int_0^{l_T} \frac{dl}{\rho} = \int_0^{l_T} \frac{dl}{M.\cot\left[\theta_0 + l * \frac{\theta_T - \theta_0}{l_T}\right] - \frac{S}{2}}$$

$$\varphi_T = \varphi_0 + \frac{l_T}{\theta_T - \theta_0} \left[\frac{M}{M^2 - \frac{S^2}{4}} \ln \frac{\cos\frac{\theta_0}{2}}{\cos^2 . \frac{\theta_T}{2}} + \frac{\frac{S}{2}}{M^2 . \frac{S^2}{4}} (\theta_T - \theta_0) \right.$$

$$\left. - \frac{M}{M^2 - \frac{S^2}{4}} \ln \left| \frac{\tan^2\frac{\theta_T}{2} - \frac{S}{M}\tan\frac{\theta_T}{2} - 1}{\tan^2\frac{\theta_0}{2} - \frac{S}{M}\tan\frac{\theta_0}{2} - 1} \right| \right]$$

The equations that determine the cartesian coordinates of the vehicle, continuously taking into consideration the constant variation of the directional wheels angle, are the following:

$$dx = dl \; . \; \cos \bar{\varphi}$$

$$dy = dl \; . \; \sin \bar{\varphi}$$

where dx represents the differential increment along the x axis, dy is the differential increment along the y axis,

dl the travelled distance and

$\bar{\varphi}$ the average turning angle $\dfrac{\varphi_1 + \varphi_2}{2}$

(see Figure 53)

Integrating:

$$X_T = X_0 + \int_0^{l_T} \cos\varphi \, dl$$

$$Y_T = Y_0 + \int_0^{l_T} \sin\varphi \, dl$$

Or by the use of numerical analysis:

$$X_T = X_0 + \sum_{i=1}^{n} dl_{i\to i+1} \cdot \cos \frac{\varphi_i + \varphi_{i+1}}{2}$$

$$Y_T = Y_0 + \sum_{i=1}^{n} dl_{i\to i+1} \cdot \sin \frac{\varphi_i + \varphi_{i+1}}{2}$$

The second embodiment is shown by the algorithm of Figure (54).

26. Wavy Course - In General

Considering a vehicle's motion on a road, we may observe that the steering wheel and the wheels perform continuous small movements to the left and to the right. The driver, estimating the distance of the vehicle from the pavement or the dividing strip, attempts to drive the vehicle with continuous corrections at the middle of the lane. The method described above [Par. (24) and (25)], refer to the vehicle's position estimation at any instant. Considering the minor corrections of vehicle's direction, the vehicle seems to outline a continuous "wavy" course [Figure (55)]. The

problem arises when the vehicle's data processing system requires information on the exact vehicle's course (e.g. the exact course curvature radius) or is required to give instructions for the exact turn of the steering wheel.

The present method allows the estimation of the average course of the vehicle, only by the readings of the directional wheels angle. The method is based on the condition that each driver follows the method of minor corrections to the vehicle's course. The steering wheel and the wheels angle of turn, to the left or to the right, take the vehicle to a wavy course. The width of the wavy course is almost the width of the lane <u>minus</u> the width of the vehicle, that is, the empty space where the vehicle moves in, without running the risk of touching the dividing strip of either the left or right lanes. The average of that width is approximately <u>3 meters</u> therefore the vehicle deviates from the average course at a maximum of ± 1.5m approximately or almost 3m in total. The problem is the marking of the average course of the vehicle and the subsequent identification, therefrom, of whether the vehicle moves correctly or along its predetermined course. Figure (56) shows the measurements of the steering wheel turning angle and the resulting measurements of the course curvature radius, considering the vehicle's wavy course in conjuction with the real curvature radius of the course. In the Figure we may observe that the measured curvature radius ρ (therefore the directional wheels turning angle) ranges from a minimal positive value of the curvature radius (corresponding to a maximal turning angle value [positive]) to an infinite value (turning angle 0). Then, the curvature radius obtains a minimal negative value (maximal negative turning angle value) and again an infinite value (turning angle 0).

Figure (56) shows on a diagram the steering wheel turning angle along the wavy course and the variation of the curvature radius.

27. Wavy Course (Straight Route)

The estimation of the real course of the vehicle in a straight route, is accomplished as follows:

Figure (57) shows the straight route of the vehicle where the various vehicle positions are noted during its wavy movement. Let O be the reference point during the vehicle's course, with cartesian coordinates for reference X_0, Y_0 and let the O, x, y, be a random reference system. For each new position of the vehicle, the angle φ between the random but constant axis x and the vehicle's polar distance from point O, is estimated. The formulas are:

$$r = \sqrt{(x-x_0)^2 + (y-y_0)^2}$$

$$\varphi = \tan^{-1}\frac{y-y_0}{x-x_0}$$

Figure (57) shows that while the vehicle is driven away from position O, the angle φ is stabilised at a value and the deviations from the average value continuously decrease.

28. Wavy Course (Lane Change)

Figure (58) shows the wavy course of a vehicle, where at a certain instant the vehicle changes lane. Let O be the reference point during the vehicle's course with cartesian coordinates X_0, Y_0 and Oxy be a random axes system. We may observe that during vehicle's straight course, the angle φ between the polar radius of vehicle position, at any instant, and the axis Ox, is stabilised to a value within continuously decreasing deviation. During the lane change, however, it is once observed a deviation from the increasingly stabilised initial angle φ and then a tendency to return at the initial angle. Thus, during vehicle's movement, the lane change is safely detected. As soon as

this is accomplished, the reference point is transferred to a position after the lane change.

29. Wavy Course (Vehicle Turn)

Let O be the reference point with cartesian coordinates X_0, Y_0 and Oxy (Figure 59) be a random system of axes. For the route until the turn, the angle φ of the polar radius of vehicle position at any instant and of the axis Ox, continuously stabilises with minor deviations at an average value. An ever increasing deviation from the initial angle φ is observed during vehicle turning. In contradiction to the lane change when after the initial deviation the angle φ tends to reach the initial angle, in the case of turning, a continuous deviation from the initial radius is observed. Apart from the detection of turning, the exact travelled distance from the given angle node is estimated as follows (Figure 60):

Let O_2 be the reference point after the detection of deviation from the initial polar angle φ_1. The angle at each point is measured by considering this point as a pole, after the point O_2 and in relation to reference axes parallel to the initial axes system. For every point beyond O_2, data of the polar distance and of the polar angle in relation to the axes systems O_1xy and O_2xy, the latter being parallel to the first one, are taken. Figure (61) shows the estimation of the centre K:

$$R_1 \cdot \cos|\varphi_2 - \varphi_1| + R_2 \cdot \cos|\varphi_2 - \varphi_0| = R$$
$$R_1 \cdot \sin|\varphi_2 - \varphi_1| = R_2 \cdot \sin|\varphi_2 - \varphi_0|$$
$$X_\varkappa = X_0 + R_1 \cdot \cos\varphi_1$$
$$Y_\varkappa = Y_0 + R_1 \cdot \sin\varphi_1$$

The turning centre is estimated for successive locations of the vehicle after point O_2. For a straight course section, the centre K will range within a small converging area.

30. Wavy Course (Successive Turns)

Figure (62) shows a vehicle's course with successive turns for a small distance. Let O be a reference point and Oxy a random system of axes. For each point, the polar angle in relation to the axis Ox is estimated. We may observe the following:

For the first segment, the polar angle is stabilised at a value with minor deviations. Then, a continuous deviation from the mean angle which continuous until the next turn is observed. After the next turn, a new deviation with a different deviation rate is observed. Figure (63) shows the graphical representation of variation of the polar angle for successive turns. The points of nodes, which are estimated with the method described hereinabove for the simple vehicle turning, may be clearly seen.

31. Description and Advantages of Wavy Course Tracking

The estimation, at any instant, of the distance travelled by the vehicle and its course curvature radius, is accomplished by the devices which are installed on board the vehicle for its real position estimation. From all the examined state-of-the-art systems:

(a) Only the present one takes into consideration the constant variation, during the course, of the directional wheels turning angle and uses integral formulas in order to estimate the direction of the vehicle. The known systems use numerical methods, considering the curvature radius for a small course section as constant. In this way, they insert an error on the determination of the vehicle position. The present method shows an exceptional accuracy at the determination of vehicle position, since the estimation of position takes into consideration the real movement of the vehicle. The requirement of identification and correction of

the position by the map-matching method is therefore less demanding.

(b) The accuracy in position estimation results to accurate instructions and control to the driver at the appropriate moment. If, the vehicle position, at any instant, were not known with accuracy, then every supporting service would be useless as long as it could not be provided to the driver at the right location.

(c) The use of polar coordinates for determining eventual deviations from the course and the execution of a turn, provides an exemptional accuracy at the estimation of vehicle position during a turn or successive turns or lane change or, finally, for identifying driver's physical condition (state of drunkness, fatigue or sleep) [Chapter e. Par. (54)]. None of the examined systems provides the driver, in such a simple way, with so many services and supports the estimation of position and movement of a vehicle. Figure (63) graphically represents the polar angle in conjunction with the distance travelled by the vehicle, whilst Figure (64) shows the general structure of the software for vehicle position estimation.

32. Transmitter and Receiver for Vehicle's Communication with other Vehicles and the Environment

The receiver of the vehicle works with and receives messages either from other vehicles' transmitters or from the transmitter network [Figure (1)] installed along the road network. In view of the uniformity of the network construction, all the transmitters that embody the present supporting method will be jointly examined. The diagram of a transmitter is shown in Figure (65a). As shown in the Figure, the said transmitter is indeed a simple encoder of a carrier wave. Thus, in every transmitter there is a mechanism of carrier wave generation (usually a stimulation

crystal) and an encoder of the signal. The encoder merely transforms the carrier wave in frequency or in width, WITHOUT HOWEVER TRANSMITTING A SPECIFIC SIGNAL. The receiver receives from the same transmitter the same code. This code corresponds to a position, a traffic police signal or anything the driver wishes to correspond the code to.

In this respect, the present system is superior to other state-of-the-art ones, that is, the said codes may be analysed or translated to any message whatsoever, depending on the database used. Thus, they may constitute a permanent subsystem connected to the existing road network, without necessitating to change it or change the transmitted codes. Likewise, the existing in-vehicle receiver, merely, divides the carrier wave from the code which is inserted in the processing system. The technology of the encoding and decoding of a signal is considered to be known to specialists and it is not mentioned herein. The in-vehicle receiver remains continuously open in order to receive signals. This method of exchanging messages through encoded signals introduces a novelty to the wireless (and cable) communication of computer systems. In the examined state-of-the-art systems, the exchange of messages and information is accomplished by a real transfer of characters or parts of the messages. The present system, is practically the communication and presentation of a DATABASE. In practice, the code number transmitted by the transmitter is the direction of the message to be transmitted to the database. Thus, for example, the code number E33 of a transmitter is connected to a section of the database of the vehicle data processing system, that receives the signal bearing the message "ATTENTION! SCHOOL, MAXIMUM SPEED 50KM/HOUR". If the driver wishes to transmit, through his/her transmitter, to another driver the message "ATTENTION! YOUR RIGHT TYRE IS DEFLATED", simply keys-in or traces out the direction code number of the database where the message is stored in, e.g. Z48. It is, of course, supposed that the database is identical to all the vehicles of the present method. The

driver receives the code number Z48 and retrieves from the database the corresponding message, "ATTENTION! YOUR VEHICLE'S RIGHT TYRE IS DEFLATED".

The advantages of this method of message transmission are many. Indicatively, two implementations are given herebelow:

* There exists no limit as to the duration or size or number or type of messages that may be transmitted. Thus, following may be transmitted:

- Texts
- Diagrams (e.g. maps)
- Sounds (e.g. siren, horn)
- Course recommendations, etc.

* The microcomputer, as long as it translates the code numbers to directions within the database and first "edits" the message, depending on its contents, occasionally presents it in a form that corresponds to the driver's needs. Therefore, for example, the reception of a diagram with a compulsory course for the vehicle in order to avoid traffic congestion, is translated by the processing system in manoeuvring instructions, such as TURN RIGHT - STRAIGHT AHEAD - TURN LEFT etc.

* The message transmission is always accurate and reliable under any environmetal conditions. Indeed, the environment in the road network is heavily burdened by noises, electromagnetic radiation, interference by radiowaves etc. The message, however, irrespective of its duration, is practically transferred by a very short code number which may be repeated for a short time i.e. E33, E33, E33. If the whole message were to be transmitted repeatedly, it would be impossible.

Another feature of the transmitters that contributes to the importance of the transmitted message, is the method of its

activation. Therefore:

* the in-vehicle transmitter may be automatically activated if the driver keys-in or traces, upon boarding on the vehicle, a certain identification code number. So, it transmits a message corresponding to the vehicle's identification and a distress signal for its tracing in case of theft.

* the in-vehicle transmitter may be activated, in one embodiment, by an inerted accelerometer and transmit a distress code S.O.S., as in case of collision.

* the transmitters of the subsystem supporting the present method, apart from the location and information code numbers, may be also automatically activated:

- due to contact with a light beam by the use of a photocell
- due to wind tracing
- due to contact with humidity
- due to fall or rise in temperature, over a certain limit, by the use of a thermistor

The automatic activation of the transmitters may be achieved by connecting them to sensors of light intensity, humidity, temperature or wind speed measurement (photometer, thermometer, windmeter), respectively, when the readings exceed certain values. Also, their automatic activation warns the approaching drivers about the road condition through the in-vehicle receiver [Chapter e - Par. (77)]. The reception of code numbers by the microcomputer results to the establishment, for example, of minimum speed limits, brake activation, change of course etc., without announcing the environmental conditions to the driver. That is, the system provides instructions understandable by the driver (i.e. manoeuvring instructions) and not simple information.

The transmitters [Figure (65a)] may be activated from a

distance by:

* tracing radiation of a certain frequency, transmitted from a central antenna or by coordinating a circuit with special signal.
* supplementing the receiver with an activation receiver.

An example of implementation of such a transmitter ability is the regulation of the traffic problem. Thus, for the traffic regulation in the large cities, dozens of transmitters and receivers of low range (500 or 1000 meters) are installed in all central locations and major crossroads. The traffic police, instead of transmitting local messages for dozens or hundreds of cases, activates those transmitters and receivers which undertake the task to transmit themselves, instead of the central station, the relevant local messages. Thus, the main transmitter is not overloaded other than for activating once. The central station also determines the transmission duration and at the scheduled time its function is interrupted. Moreover, it is also determined whether the message will be periodically trasnmitted. These messages may be more than one for different vehicles and/or more messages for the same vehicles. Most of the transmitters and receivers may transmit any kind of code number, in the same way as the main transmitters. Therefore, depending on the needs, 10, 500 or 1000 transmitters and receivers may be activated.

Public use vehicles that often need to have priority (fire-fighting vehicles, police cars, ambulances etc.) or vehicles that drivers of other ones need to pay attention to, such as school buses, transmit during their motion the special code number which is translated by the processing system into instructions concerning manoeuvres for granting priority or special attention. Thus, the reception by the receivers of the vehicles moving within the area of signal transmission, e.g. "priority to an ambulance", is possible and this signal corresponds to the transmission of instructions to the

drivers, having the guidance system and the present invention on board their vehicles, in order to evacuate a lane. Likewise, minimum speed limits are automatically established upon the approaching of a school bus.

* Finally, a feature of this method that allows the selective message reception is when the encoded signal transmitted is accompanied by an encoded signal of the location or position. In this case, the in-vehicle receiver is always on. The vehicle data processing system, however, is able to select, from the codes received, only those that concern the following:

- the particular vehicle (its code number or licence plates number)
- the particular type of vehicle
- the destination of the vehicle
- the scheduled course to be followed

This is accomplished in the simplest way by comparing the contents of the code with the identification of the vehicle or the course data. For example, code number that concern fire in a building located in the road network, concern fire-fighting vehicles and are decoded or translated into instructions only by them. They may not be decoded by trucks, for example, unless a deviation from the course or granting of priority to another vehicle are required. In this way, without the use of communication channels, for example, the selective communication even with individual vehicles or vehicles moving in special areas or directed to special areas, is possible. None of the examined similar state-of-the-art systems does it provide this ability.

<u>Distance estimation by a transmitter of simultaneous signal transmission in E/M frequency and Acoustic frequency</u>

In this case, transmitters that simultaneously transmit signals in E/M frequency and Acoustic radiation are used.

The signal in the E/M frequency (e.g. 210 MHz) is instantaneously received by the in-vehicle receiver as described hereinabove. A second receiver that receives signal in acoustic frequencies (e.g. supersonic of 30000 Hz) [Figure (65b)] is used. This signal, although transmitted simultaneously with the E/M radiation signal, moves much slower than the latter (340 m/sec) and therefore it is not instantaneously received but with a delay (e.g. 10 msec later than the signal of the E/M radiation). This time delay, measured by the vehicle data processing system and multiplied by the speed of sound (340 m/sec), guides to the estimation of the distance between the vehicle and the transmitter. This case, in combination with other vehicle position estimation methods [Chapter d - Par. (55)] and direction estimation, significantly facilitates the position and direction estimation by the use of a limited number of transmitters. This occurs as the vehicle is traced within the range of each transmitter with another more accurate method for short courses, provided that the distance from the transmitter and the direction it moves toward are known. The transmitter network maps-out wider areas, special spaces (garages, docks) etc., where by the use of a limited number of transmitters, one may estimate (a) whether the vehicle has entered into the subject area and (b) the exact location from the transmitter reference point.

33. Turn and Direction Identification Compass

It concerns a simple orientation compass that accompanies the vehicle position estimation service, supported by a transmitter subsystem installed in traffic nodes. The use of the compass enables the exact estimation of the direction the vehicle moves towards, at the time of its arrival at and departure from the node. The state-of-the-art systems use a compass combined with a method of travelled distance measurement by an odometer in order to determine the vehicle position in the autonomous guidance systems. In the present

method, the compass is used combined with a transmitter subsystem for more complete registration of the vehicle direction entry to and exit from the node. An advantage of such a compass use is the fact that it does not require a signal reception from the previous or next transmitter of the subsystem in order to identify the direction the vehicle moves towards, but just the reception of the signal from one transmitter and from the compass confirms the direction the vehicle comes from and moves towards. Another advantage of the use of the compass in combination with a position network subsystem is the fact that a position transmitter covers more than one adjacent nodes. In fact, within the reception range of the transmitter signal, the vehicle may manoeuvre e.g. by turning in narrow roads, without loosing its orientation as long as the compass monitors the course changes instead of the transmitter. Thus, a lower number of transmitters cover a wider area, each transmitter covering many adjacent nodes.

In a first embodiment, the service is provided as follows:

The compass used is a magnetic one of common type or in another embodiment it is a gyroscopic one. Its readings e.g. in degrees, are inserted to the in-vehicle microcomputer as permanent data [Figure (66)]. On the other hand, the encoded signal of each transmitter is connected, in the memory unit, with more than one values in degrees, apart from the connection with position topographic data or other elements, depending on the number of roads connected with the particular node (e.g. if two roads are crossed on the node covered by the same transmitter, two values in degrees are given, such as A=56° or B=154° [Figure (67)]. If upon reception of the transmitter signal the vehicle compass reads for example 56 degrees, then [see Figure (67)] it is located at position (1) and enters into the node. If the vehicle entered into the node from position (3), the reading would be (56 + 180 degrees). Moreover, if after the signal reception the compass readings change to 154 degrees, then

the vehicle drives away from the node towards direction (4). If when it received the signal for the first time the readings were 154 degrees, then the vehicle would come from direction (2). It is understood that the registration of direction degrees in connection with each node, follows the same logic in every node for uniform processing. In case of nodes with particularities (e.g. multilevelled nodes with many junctions), the node code number, upon its reception, may retrieve from the memory unit more information regarding the direction and the movement of the vehicle in respect with the compass, such as monitoring of the compass readings whilst the vehicle moves on the ramps of the level change etc.

34. Echo-transmission and Echo-mapping

(a) Echo-transmission

Method of estimation of vehicle position on the road network by the use of acoustic or other radiation frequency reflection on fixed obstacles, to the right or left of the road surface. The method is based on the signal transmission in a spectrum range of the E/M radiation, which is reflected on fixed obstacles (UHF,infrared) or acoustic supersonic waves. The transmission of such signals is directed, by preference, in a transversal way to the vehicle movement. The method also provides the reception of the signal, so reflected, by a reception device. When the vehicle moves on the road network of a rural area, the signal transmitted in a transversal way to the vehicle movement, is reflected on the buildings located to the left or to the right of the road, whilst the reflected signal is received by the reception device. If however the vehicle during its movement passes from a crossroad, then the signal transmitted by the vehicle, is not reflected on a fixed obstacle and therefore it cannot be received by the reception device. This phenomenon is used for vehicle position estimation on the road network of rural areas.

None of the state-of-the-art systems does refer to vehicle position identification by transmission and reflection of signals on fixed obstacles at both sides of the road network. It is only mentioned the case of use of transmission and reception of reflected signal for the estimation of a vehicle position in relation to other vehicle position on the road surface. Also, the method of transmission and reception of reflected signal is used in order to avoid obstacles along the vehicle course. In the present method, the transmission and reception of the reflected signal is used for the estimation and identification of the vehicle position on the road surface and particularly in relation to the areas and buildings at both sides of the road network. The advantages of the present method are the following:

(1) The topography not only of the road surface but of the surrounding area as well, is used on the estimation of vehicle position.

(2) The vehicle position identification is accomplished in such a way so that the driver may confirm it, that is in relation to the vehicle passage from crossroads [Chapter d, Par. (38)].

(3) The success of the identification may be directly checked by the driver by transmission of e.g. acoustic signals. Thus, during the passage from a crossroad, the driver may directly check whether the vehicle position identification was carried out and in the negative, to interfere with the position estimation (e.g. by using some kind of manual method of estimation).

(4) The method is particularly useful for the tracking of entry in an unregistered area (unmapped) within the memory unit. During the exit from the registered road network in the memory unit (e.g. turning right in a narrow road), the acoustic or other signal is transmitted along the road

network and it is not reflected [Figure (68)]. It is therefore shown the exit of the vehicle from its normal course, especially when, at that point, no turn is provided by the data registered in the memory unit.

(5) Finally, this method is the only one that guarantees the vehicle position identification without external assistance (e.g. from a transmitters subsystem or satellites) and without the support of an odometer.

(6) A characteristic of the vehicle position identification method is that during the passage from a crossroad, the driver is informed of the position identification by a distinctive sound. If the position identification by the present method is not accomplished (e.g. when a massive vehicle passes by the subject vehicle at the moment of identification), the lack of the distinctive signal again leads the driver to interfere manually provided that he/she notices the passage from the crossroad and does not hear the distinctive sound.

The method, as aforementioned, is based on the transmission of a signal in the frequency of the E/M radiation, which guarantees the reflection on a fixed obstacle. The signal is transmitted, in a first embodiment, in an acoustic frequency (e.g. supersonic), whist in a second embodiment it may be a pulse of transmission with limited duration (e.g. 10 ms) followed by a pause of longer duration (e.g. 15 ms). The pausing time is defined in such away, so that for the larger width of a road, the pulse has the time limit to transversely run the road, to be reflected and return prior to the transmission of the next pulse.

An example of using the acoustic frequency with spreading speed the speed of sound, that is almost 340 m/sec, is the following:

For a road with width 30 m, the signal requires the

following time to run from one edge to the other, to refract and return:

time t=S/U=60/340 sec=0.19 sec

Therefore the pausing time must be higher or equal to 0.19 sec or 190 ms.

The devices that embody the method are the following [Figure (69)]:

(a) Carrier wave generator (1)
(b) Modulator (2)

Those two devices are connected with the vehicle data processing system (5) and coordinate the transmission of pulses in the selected frequency of the E/M radiation. The processing system coordinates the time periods of transmission and pausing.

(c) The modulated signal is inserted in the signal transmission device (3) which is an amplifier and is transmitted from the transmission antenna.

(d) The antenna (4) is of directed transmission, with its main reflectors transversely directed to the right and left in relation to the vehicle direction [Figure (70)].

The signal is transmitted by the antenna of directed transmission (4) and is reflected on obstacles to the right and left of the road [Figure (71)]. Thereafter, as soon as it is reflected, it is received by the reception antenna (6) which consist of two reflectors for the reception of the reflected signal from the right of the vehicle and for the reception of the signal from the left of the vehicle. The said antenna is connected with the receiver (7), which is in turn connected with the vehicle data processing system (5).

The device operates as follows [Figure (69)]:

The data processing system (5) triggers in fixed time periods e.g. every 1 sec. the generator (1) and the modulator (2) in order to transmit a pulse, at the same time defining its duration (e.g. 10 ms). As soon as the signal is transmitted, the data processing system (5) waits for the receiver signal, which through the reception antenna receives the reflected signal separately from the right and from the left sides of the road. Depending on the time intervening between transmission and reception, following conclusions are reached [Table (7)]:

(Signal transmission speed U = 340 m/sec)

Figure (72) shows the method of verification of arrival at a crossroad. During the passage from the crossroad, since there are no obstacles to the right and to the left of the road, the reception time of the required signal is indefinite and therefore the data processing system refers to case 1, that is execution of a turn or passage from a crossroad. The antennas of directed transmission and reception are installed in adequate height above the vehicle in order to avoid, as much as possible, that the signal strikes against and is reflected on nearby moving vehicles. However, as aforementioned, the driver has the ability to confirm or not the source of signal reflection due to direct vision contact.

(b) Method of Echo-mapping

This method uses the devices of the Echo-transmission method [Figure (69)], in order to register the time intervening between transmission and reception of the reflected signal during the vehicle passage from road sections between two nodes. The registration of the time interval between transmission and reception of the reflected signal, is effected during the time that no other vehicles pass through

TIME BETW. RECEPTION & TRANSMISSION	DISTANCE FROM THE OBSTACLE	CONCLUSION	
INFINITE	INFINITE	PASSAGE FROM A CROSSROAD-EXECUTION OF A TURN	
VERY LONG $\geq$ 1 sec	VERY LONG $\geq$ 160m	PASSAGE FROM A LARGE CENTRAL ARTERIAL ROAD LACK OF BUILDINGS TO THE RIGHT & LEFT OF THE ROAD. LACK OF PROTECTIVE BARS	
LONG (0.5 - 1 sec)	LONG (80-160 m)	PASSAGE FROM AN ARTERIAL ROAD OF LARGE WIDTH	
MEDIUM (0.2 - 0.5 sec)	MODERATE (32-80 m)	PASSAGE FROM CENTRAL ART.ROAD	SIGNAL SPEED U=340 m/sec
SHORT (0.1 - 0.2 sec)	(16-32 m)	PASSAGE FROM A ROAD	
(0.05- 0.1 sec)	(8-16 m)	PASSAGE FROM A ROAD	
(0.02- 0.05 sec)	(3- 8 m)	PASSAGE FROM A ROAD OR NEARBY VEHICLE	
(0.01- 0.02 sec)	(1.5-3 m)	NEARBY VEHICLE	
($\leq$ 0.01 sec)	($\leq$ 1.5 m)	NEARBY VEHICLE	

TABLE (7) - CONCLUSIONS REACHED FROM THE TIME LAG BETWEEN SIGNAL RECEPTION & TRANSMISSION

the particular section of the road network (e.g. after midnight), so that the registered data are not falsified by other vehicles' passage. Signals are transmitted every certain meters of the vehicle's course. This is accomplished as follows:

Figure (69) of the Echo-transmission method shows the connection of the data processing system with the odometer (8) of the vehicle. Every certain (always the same) travelled distance (e.g. 5 m), the microcomputer activates the pulse transmission device and registers the reception time of the right-side reflected signal and the reception time of the left-side reflected signal, for the distance travelled by the vehicle from one node (e.g. node 36) to the next adjacent one (e.g. node 73). The vehicle in order to receive such data moves always on the same lane (e.g. the far end right lane). From that lane, the transmission and reception times of the reflected signal to the right and left of the vehicle movement are registered. Table (8) shows the form of data registered in the memory unit. The registration of said data is combined with the Echo-transmission method in order to track and verify the vehicle position on the road network.
In the said echo-transmission method, the latter was used in order to verify vehicle's passage from crossroads, where the reflected signal was not received by the reception antenna. However, in combination with the present registration method of the time between signal transmission and reception, following conclusions are reached:

(1) It was stated that the registration of time between reflected signal reception and transmission is accomplished during vehicle's movement along a lane e.g. the far end at the right side [Lane 1 in Figure (71)]. If the measured time during the real vehicle course for signal transmission in equal intervals (e.g. 5 m) are steadily different at an integral part from the registered ones and particularly if

DEPARTURE NODE CODE NUMBER :	53
DESTINATION NODE CODE NUMBER :	68
COURSE LENGTH (m) :	350
LANE NUMBER (FROM THE RIGHT SIDE) :	1
SIGNAL TRANSM.TRAVELLED DIST. (m) :	5
TIME BETWEEN TRANSMISSION-RECEPTION: OF RIGHT-SIDE SIGNAL (msec) :	10
TIME BETWEEN TRANSMISSION-RECEPTION: OF LEFT-SIDE SIGNAL (msec) :	35
TIME BETWEEN TRANSMISSION-RECEPTION: OF RIGHT-SIDE SIGNAL (msec) :	12
TIME BETWEEN TRANSMISSION-RECEPTION: OF LEFT-SIDE SIGNAL (msec) :	43
TIME BETWEEN TRANSMISSION-RECEPTION: OF RIGHT-SIDE SIGNAL (msec) :	11
TIME BETWEEN TRANSMISSION-RECEPTION: OF LEFT-SIDE SIGNAL (msec) :	41
TIME BETWEEN TRANSMISSION-RECEPTION: OF RIGHT-SIDE SIGNAL (msec) :	10
TIME BETWEEN TRANSMISSION-RECEPTION: OF LEFT-SIDE SIGNAL (msec) :	43
etc.	etc.

TABLE (8) - FORM OF DATA REGISTRATION BY ECHO-TRANSMISSION

the extra time of the signal transmitted from right is the same with the missing time of the left-side transmitted signal, this is an indication that the vehicle moves on a different lane from the one registered in the data of echo-mapping method.

(2) If eventually the time between transmission and reception of the transmitted signal coincide with the ones registered in the memory unit, and however, for a short period, one of them, after being measured during vehicle movement,appears to be shorter than the registered one (e.g. the left-side one) this constitutes an indication for another vehicle passage from the left side of the subject vehicle. Similar conclusions are reached in case of left-sided signal indication.

(3) If during movement along a section between two nodes, an infinite or very long time between transmission and reception of reflected signal from the left side is measured, this constitutes an indication that the vehicle turns to the right. The opposite occurs for measuring an infinite or very long time for the reception of signal reflected from the right side, in case of a left turn. Figure (72) shows the said case.

(4) If the parking of a vehicle to the left or right side of the street requires manoeuvres, the time between the transmission and reception of a reflected signal, which is registered in the memory unit, substantially constitutes measurement of the vehicle position with respect to the road surface. Thus, for the support of the driver, in order to accomplish accurate parking manoeuvres [Chapter f - Par. 88], the measured time for the reception of the reflected signal is used to define the exact vehicle position and thereafter to provide instructions for accurate manoeuvring during parking.

(5) Finally, the present method of echo-mapping, combined

with the method of echo-transmission, is used in the verification of the execution of turn during passage from nodes. The turn verification method, during the passage from a node, is characterised by the monitoring of course sections on the node, during which an infinite or very long reflection time was measured. Figure (72) shows a verification of execution of turn from the survey of the sections where infinite times of reflected signal reception were measured. The said Figure accurately shows the turn of the vehicle at the fifth, from the entrance point of view, road by measuring three areas of infinite time of reflected signal reception.

(6) Finally, the present method of echo-mapping is the only one being implemented for the determination of the vehicle position in wide areas, where the road network is not outlined, for example large parking areas, yards, sports fields, etc. In these areas, the time of reception of the reflected signal is an indication of the vehicle position with respect to existing obstacles to the right and to the left. Figure (73) represents the devices that embody all the stated methods of tracking, confirmation and verification of vehicle position that are connected with the data processing system.

35. Vehicle's Position Identification - In General

The method presupposes more than one methods of vehicle position identification, on the road network, at any instant. Those methods supplement and compare with each other so that the vehicle position on the road network is confirmed by more than one sources. Moreover, the method presupposes more than one methods for the correction of vehicle position, as it is estimated by the microcomputer, so that it agrees with the real vehicle position on the road network. This characteristic of the present method, that is the vehicle position verification by several methods, is

deemed to be necessary as it is very significant for the microcomputer when estimating the vehicle real position for almost all the supporting services it provides. The majority of the examined inventions provide only one method of position verification. In fact, the supporting services of the present method depend on the eventual position where according to the data processing system the vehicle is located at, in relation to the road network as registered in the memory unit.

Thus, while the driver determines and monitors the vehicle movement in relation to its real position in any instant, in the real road network the on-board microcomputer provides the supporting services in relation to the vehicle position estimated by the microcomputer compared to the registered data of the road network. If eventually the microcomputer estimates an erroneous vehicle position or the registered data do not agree with the real road network data, then the guidance instructions provided by the method, will refer to a DIFFERENT INSTANT OR POSITION THAN THE REQUIRED ONE. In the first method embodiment, following will be presented:

(a) Methods of estimating the initial vehicle position during starting-off.
(b) Methods of estimating the exact vehicle position at any instant, during a course.
(c) Methods of correcting the vehicle position estimated by the data processing system in relation to its real position.
Those three methods consider that the registered in the memory unit road network data,, fully agree with the real ones.
(d) Methods of correcting the road network data registered in the memory unit in relation to the real data in case of disagreement.

Those methods are based on three effectiveness factors, that is:

* the driver

* the devices embodying the method
* the data registered in the memory unit

36. Vehicle's Initial Position Estimation

(a) One of the devices mentioned in Chapter a - Par. (1), has been stated to be the memory unit which is highly protected against thermal, mechanical, chemical wear or radiation influences and that the data processed by the in-vehicle microcomputer during the last course section [Chapter g - Par. (91)] are registered therein.

Therefore, in this unit the immobilisation position of the vehicle is maintained as a last data. This vehicle position is given by the two nodes and the distance from the entry node where it is located at. This data, during the new departure of the vehicle, is inserted as the initial position.

(b) Apart from the highly protected memory unit, a memory address is available in the regular memory unit where the vehicle position is registered in any instant. From the said position, upon vehicle's starting, the last registered position is edited and constitutes the new starting position.

(c) Transmitter's signal reception. It has been stated that the method is combined with the use of a transmitters' subsystem installed alongside the road network [Chapter d - Par. (32)]. The reception, by the vehicle's receiver, of a transmitter's signal is translated by the microcomputer to vehicle position NEAR THE AREA where this transmitter is installed. The signal reception from one transmitter only is not possible to define the real vehicle position, since reception takes place at any point within the transmitter's range of transmission.

For the exact location following is required:

- Reception of a signal from a second transmitter, as soon as the vehicle starts, where the location of the first reception of a transmitter and the location of the second reception of a transmitter, allow with a sufficient accuracy the estimation of the vehicle position in the distance in-between.

- Use of the odometers for estimating the distance travelled by the vehicle and of the sensors of directional wheels' turn. The use of those devices allows the exact estimation of the initial position, provided that the approximate initial position is known by the signal of the transmitters or only one transmitter. Example: The vehicle receives the signal of a transmitter which corresponds to a transmitter installed in the section between nodes 33 and 55 in a distance of 150 metres from node 33 and 350 metres from node 55. If the transmitter's range is 50 metres approximately, the vehicle is located between nodes 33 and 55, in a distance greater than 100 metres from node 33 and greater than 300 metres from node 55 [Figure (74)]. If the vehicle's odometer registeres a course of 340 metres to the nearest node, then the initial vehicle position is exactly between nodes 33 and 55, in a distance of 340 metres directed towards node 55. In case of signal reception from two successive transmitters, the use of odometers expeditiously shows the exact vehicle position.

(d) Use by the in-vehicle devices of: 1) the odometer for measuring the distance travelled by the vehicle and 2) the device measuring the transversal angle of the directional wheels for verifying the turn at a node and the road network information registered in the memory unit.

The driver performs a random course from the parking position, turning (right or left) at the first encountered nodes. The microcomputer, taking into consideration the road

network data, may estimate the vehicle position after it has passed through a minimal number of nodes, as follows:

* Upon arrival of the vehicle at the first node, the odometer measures the travelled distance until the next node. With the travelled distance between the two nodes as a data, the microcomputer isolates the course sections between two nodes of a particular area which are characterised by the measured length. Let 12 be the number of course sections. Upon arrival at each node the driver turns in an angle (which is inserted as a data in the microcomputer from the transversal angle of the directional wheels in conjuction with the distance measured by the odometer). Thus, upon arrival at the second node, the driver turns and enters into a new course section between two nodes, whilst the odometer indicates the travelled distance till the third node in the row. The microcomputer selects among the first course sections which were chosen (12 from the example), the consecutive course sections that correspond to the particular turning angle. In this first selection from the 12 initial courses, those that are not connected with courses of the turning angle in question, are rejected. It has to be noted that for courses of bi-directional circulation, the possibility of directing to both opposite lanes is examined. From the remaining consecutive courses, those with course length non-coinciding with the measured new one, are rejected. Thus, from the 12 initial courses, let 7 be rejected and 5 remain with a course section, identical to the one measured from the second to the third node, corresponding to the latter.

* Upon arrival of the vehicle at the third node in the row, a turn is selected and the new distance is measured. Again from the remaining 5 initial courses, those for which the second and third courses do not coincide, from the topographic data, are rejected. The procedure continues until the initial selections are all, but one real vehicle course, are rejected. The said course is verified when,

after the estimation of one remaining initial course, the vehicle is driven in the new section between two nodes turning in an angle so that the microcomputer confirms the said one course with new data.

37. Position Verification during the course (AUTOMATICALLY)

By the term "position verification of the vehicle" we signify, as aforementioned, the following:

The position estimated by the data processing system as the vehicle position, in relation to the road network registered data, that coincides at any instant with the real vehicle position in the real road network. The automatic verification of the position at any instant, if the initial vehicle starting position is known, is determined by the distance travelled by the vehicle, as measured by the odometer and the turning angle of the directional wheels of the vehicle. From those two devices the vehicle position at any instant is estimated as given herebelow, as long as the initial vehicle starting position and the initial direction are known:

* From the starting position, the vehicle travels a real distance l [Figure (75)].
* The vehicle's odometer measures, as travelled, the distance l_1 (this is the travelled distance as considered by the in-vehicle microcomputer).
* From the real starting position A, the vehicle is found in position B.
* The microcomputer, based on the odometer's indication, considers - in relation to the topology network data - that the vehicle is found in position B_1 [Figure (75)]. The new vehicle position B_1 coincides with the real position B, provided that:

(a) the odometer measures the exact distance travelled

(b) the real starting position A_1 coincides with the real

starting position A.
(c) the road network data, as registered in the memory unit, coincide with the real road netword data.

Under these conditions, the microcomputer estimates at any instant the real vehicle position on the road network. This procedure continues for the whole distance between the two nodes. Upon arrival at a particular node, the microcomputer, in order to continue the procedure of estimating the vehicle position for the new course section, has to know in which of the course sections, that the node is connected to, the vehicle course will continue. This information is provided by the indication of the directional wheels transversal angle of turn in conjunction with the odometer's reading, for the estimation of vehicle's angle of turn, which is a method described in Chapter d - Par. (24). The data of the eventual node from a topology, formation and other points of view are described in Chapter b.

From the above data, the microcomputer is informed of the new course section which is to be travelled by the vehicle, as well as the initial odometer readings when the vehicle enters into the new course. From the new initial position, from the road network data concerning the new course section, and only from the indication of the travelled distance which is measured by the odometer, the microcomputer estimates the new vehicle position, at any instant, for the new course section. The estimated, by the microcomputer, new position B_1 of the vehicle does not coincide with the real vehicle position in the following cases:

(a) Erroneous registration of the road network data in the memory unit.
(b) Change in the data of the road network (one-way streets, entrance prohibition) which is not yet registered in the database.
(c) Erroneous measurement of the travelled distance from the

odometer due to:

* Bad calibration of the odometer
* Loss in tyres' pressure (deflation)
* Tyres' wear
* Vehicle movement transversely to the road surface, when the travelled distance does not measure the new vehicle position (e.g. when changing lanes or performing overtaking manoeuvres)

(d) Wheel slide when the vehicle moves without the appropriate wheel rotation (e.g. in case of rain, ice, blocked handbrake etc.).

(e) Compulsory deviation from a road network section (e.g. due to repairs or an accident).

(f) Reverse vehicle course during its movement on a course section.

(g) Temporary vehicle movement on a network section which is not registered in the memory unit and return to the registered road network section (e.g. entry in a a petrol station, garage yard or multi-levelled parkings, etc.).

Due to these errors, the vehicle position - estimated by the microcomputer - does not coincide with the real vehicle position, at any time, on the real road network. In order to correct the error, it is therefore required to:

- Estimate the exact position
- Verify the exact position
- Correct the vehicle position estimated by the microcomputer

The present method uses two methods for accomplishment of the above:

(1) Continuous position estimation, verification and correction

(2) Estimation, verification and correction in certain points of the road network

38. Map-Matching Methods

(a) Continuous position estimation, verification and correction (AUTOMATICALLY)

The present method uses this way to correct errors concerning the vehicle's position, arising from various sources during the whole course. The data processing system is automatically informed of the existence of sources producing continuous errors as follows:

(1) If, after a correction to the vehicle position, by methods described herebelow, the error is repeated, this indicates that a permanent error cause exists.
(2) If, in every correction of the vehicle position, by methods described herebelow, the error corrected is proportional to the travelled distance (the greater the distance travelled before the correction, the greater the error), then a cause for continuous error exists.

This second characteristic constitute the main feature of continuous error, that is the continuous error is proportional to the travelled distance. The continuous correction to the vehicle position, due to the permanent error, is simple and is automatically performed by the microcomputer as follows:

The microcomputer does not take into consideration the real indication of the travelled distance l_1 as measured by the odometer, but a "corrected" one

$$l_{1'} = K \cdot l_1$$

(where K is the correction factor)

The correction factor is estimated as follows:

In every correction of the vehicle position in relation to its real position on the road network, the deviation from the position estimated by the microcomputer is measured with

comparison to the real one. This error is divided by the measured distance and the error per unit of course length is calculated:

Example

* Real vehicle position A.
* Vehicle position estimated by the microcomputer Σ, e.g. 5 metres (position error)
* Travelled distance as measured from the last correction is l_1 (e.g. 270 m)
* Error per course unit:

$$\sigma = \frac{\Sigma}{l_1}$$

or, for example,

$$\sigma = \frac{-5}{270} = 0.0185$$

If the error per course unit of length is repeated in every position correction with a deviation limit δ (e.g. 5%), that is, every σ measured is different to the others upto 5%, then the microcomputer accepts the existence of permanent error cause and estimates the correction factor K as follows:

$$\sigma = \frac{\Sigma}{l_1}$$

l_1= measured distance
Σ= position error

Real travelled distance:

$$l = l_1 + \Sigma$$

Correction factor:

$$K = \frac{l}{l_1} = \frac{l_1 + \Sigma}{l_1} = 1 + \frac{\Sigma}{l_1} = 1 + \sigma$$

$$K = 1 + \sigma$$

Note: If σ for two consecutive corrections is found to be the same, then outside the limits, but at the next

correction it is identical to the initial ones, then the microcomputer for the estimation of the correction factor ignores the intermediate deviation outside the limits. This is probably due to a local cause. As a result of the automatic error correction by the said service, the general registration, in a scale, of the road network data in the memory unit and the automatic determination of the factor, that translates the scale in the travelled distance, are allowed.

(b) Interrupted estimation, verification and vehicle position correction

(1) Manual Method

During the course, the driver attempts to locate the number and the name of the street, As soon as he/she locates the number, at the corner of the street, presses the initialisation key, for indentification of the start of measurement. Thus, the driver is aware that the measurement starts at the particular street which he/she will enter and particularly at the specific street block (which is found by the number as well as by the street direction). The driver is aware of the street direction as the odd numbers increase on the left side, the even numbers increase on the right side and to the opposite when an odd number is located on the right side, the odd numbers are reduced and on the left side the even numbers are reduced. If the driver keys-in a reduction or an increase and the next number he/she is supposed to pursue, then the microcomputer is aware of the direction.

Therefore, it suffices to have the particulars of the street, the block where the number belongs to and the direction, in order to enable the microcomputer being aware of the vehicle position.

(2) Manual Method

a) The system's matching key to the nearest crossroad. Let the vehicle be located between two crossroads. The method provides that as soon as the calibration (initialisation) key is pressed once, the system ignores the position indicated by the odometer and transfers the measurement to the nearest crossroad. If the nearest crossroad is the last one, then measurement is resumed from that point, whilst if the nearest crossroad is the next one, the system considers the distance travelled and starts the measurement from that point. So, if the driver presses the key in a crossroad, possible accumulated positive and negative errors of the odometer will be revealed. The driver has to press the calibration key whilst at the centre of each crossroad. In case that there are very close crossroads, it is possible that erroneous calibration may occur. In crossroads, however, of larger blocks, correct calibration is ensured.

b) Matching key with petrol stations. Due to the fact that the petrol stations are always located on the street sides and have an exit, the mapping includes the said position as a crossroad so that the driver may calibrate by the above method. It is certain and particularly in large distances where "loss" of a few meters by the odometer is is possible for various reasons, that the pressing of the calibration key twice rectifies the situation, mainly when the particular petrol station is away from another one. The calibration in this case is not carried out from a crossroad to another crossroad but from a petrol station to another petrol station.

Due to the fact that the average distance between the two stations is probably 20 or 50 times larger than the average one of the crossroads, it is shown that irrespective of the meters lost by the vehicle, by pressing the calibration key twice, the vehicle is again calibrated.

(3) Method of Automatic Matching with different code numbers

The installation of two consecutive microtransmitters (which transmit code numbers) allows the receiver -upon reception of their signals- to be immediately aware of the position and the direction of the vehicle and subsequently the measurement. The transmitter identifies the receiver as real and ignores the indication of the odometer that had "lost" the correct course. The code numbers of the microtransmitter are registered in the data processing system and signify the determined location.

(4) Automatic Method with Transmitter - Compass

See Par. (33) - Compass.

(5) Automatic Method of Map-Matching from turn to turn

Automatic correction by data comparison. Let us assume that the odometer has "lost" some meters and guides the driver to the wrong street. If the vehicle turns and the angle is correct, it will accept that the turn is real, if however, the lengths of the set course do not match, the microcomputer checks them with comparison to the data of the adjacent roads. Thus,, it may quickly locate its real position and reroute [the method of angle measurement is described in Chapter d - Par. (24)].

(6) Automatic Map-Matching Method in small turns (excluding the crossroads)

In the processing unit of the system, the street curvature, particularly of the main streets and for a certain distance, in relation to the straight line, is registered. When the vehicle moves on a straight line, the method conceives this curvature [Par. (24)] and thus it compares it to the readings of the odometer in order to conclude if the correct position is shown. In a different case, it

calibrates depending on the identified curvature. The street curvature is registered in the form of length and angle. Therefore, vehicle's manoeuvres on the road are not considered as a given curvature. The position confirmation is accomplished when a second registered slope is met, when the connection of the two slopes in degrees with the duration of a turn and mainly with the distance between them, confirms the correctness of data.

<u>(7) Automatic Method of Map-Matching with street inclination (Acclivity - Declivity)</u>

It has been stated in the description of the data being registered in the microcomputer's memory unit, that the longitudinal slope of the road surface is also registered among others. In another service of the present method, the approaches for monitoring vehicle and street slope by the detailed examination of the odometer readings, are presented. The comparison of the measured vehicle slope to the street slope as it is registered in the memory unit, confirms the vehicle position on the road network. Thus, if acclivity is detected by the odometer's readings, at a point where the memory unit data presents declivity, it consists an evidence that the vehicle's real position does not coincide with the popsition identified by the microcomputer. The main advantage of this position identification method is that it covers the needs of position estimation and guidance through roads without nodes and other auxiliary position estimation data, such as passage through mountains, provincial roads, passage through valleys etc. Those roads are difficult to be covered by other means of position estimation (e.g. transmitters, integration of the travelled distance, compass etc.) mainly due to the large courses and the extreme meteorological conditions that do reduce the effectiveness of other methods. Another advantageous use of this method is the position estimation within areas where the vehicle's ascent to or descent from other levels is

required. Such implementations are for example the ramps of multi-levelled parking stations or traffic nodes that connect streets of different levels etc.

(8) Automatic Method by Echo-transmission

The different noise heard during driving through the crossroads, is easily detected through the sense of hearing. With a noise measuring device the position and the width of the streets encountered by the vehicle may be detected. Thus, a continuous monitoring of the crossroads is compared to the mapping of the database and confirms vehicle position. A large number of monitored crossroads always gives a correct average. During the monitoring of individual crossroads, where vehicles drive through, an erroneous indication may be given. By the echo-transmission method, an echo-mapping of the area where the vehicle moves in, is given [see Method of Echo-transmission and Echo-mapping in chapter d - Par. (34)].

(9) Method of unmapped area

a) The case of x′ - y′ course

Due to the fact that each vehicle is often found within unmapped areas (petrol stations, yards, repairshops, parkings etc.) it is required that the driver does not need to estimate his/her position each time. In this case, the method of vehicle's x′ - y′ course in relation to the elements of the square or the polygon, one side of which the vehicle course has intersected, is used. The data processing system being aware of the length of the sides and the included angles of the square or the polygon, calculates its dimensions and comparing them to the x′-y′ course it is derived whether the vehicle intersected another side, at which point and towards which direction. The guidance is then continued with the map-matching method and the smooth collaboration between the two methods is achieved.

b) **The case of interruption of measurement**

When the microcomputer identifies that the vehicle entered into an unmapped area, vocally announces it to the driver. Then the driver presses a key that interrupts the measurement by the sensors when the vehicle is still on a straight course.

When the driver returns to the same point and aligns the vehicle with the mapped street, he/she activates the sensors again by pressing the appropriate key and thus the interrupted routing is resumed.

39. Navigation - In general

As soon as the course to be followed by the vehicle from an origin to a destination point is estimated, the method provides a driver navigation service towards his/her destination. This service may be divided into the following general subservices.

a. Guidance for manoeuvres and movements required for the course along a route.

b. Guidance for manoeuvres and movements required for the course in special sections of the road network (e.g. multi-branches, turns).

c. Guidance for manoeuvres and movements:
 * in special areas (e.g. parking in a specific location, movement in a garage, in docks etc.)
 * of special type vehicles (e.g. towed)
 * of special type driving or driving under specifications (e.g. racing etc.)

d. Guidance and notification for avoiding traffic congestion.

40. Guidance for Course along a Route

This service is provided in two cases, that is:

(a) In case that the course to be followed by the vehicle is specified in the manner described by Chapter c.

(b) In case that the vehicle course is not determined and the driver drives without the microcomputer having specified the course. In this case, the microcomputer performs the following procedure in order to detect the possible course to be followed by the vehicle and provide the necessary guidance service concerning the course. This procedure is as follows:

** The data registered in the microcomputer's memory unit are stated in Chapter b.
** The vehicle position on the road network, at any instant, is found by methods stated in Chapter d - Par. (35).

On the basis of above data, the microcomputer "decides" on the most probable next course of the vehicle as follows:

(1) If the vehicle moves in a low-level course [Chapter c Par. (21)], e.g. district network, then the most probable course is the one that guides to a course of higher level. Thus, if the vehicle approaches a node where courses start from, and one of them leads to a course of higher level, the microcomputer will consider the latter as the most probable course.

(2) If the vehicle moves in a course that crosses a street of priority, the microcomputer considers the course on the priority street as the most probable one.

(3) If the node, the vehicle is directed to, does not connect with one of the above courses, the microcomputer

considers as the most probable course the straight one in relation to the arrival course, whilst as a second probability the right course and as less probable the left course.

(4) Depending on the lane the vehicle moves on during its approach to a node, the microcomputer decides on the further course e.g. right lane, right turn. For these cases, the instructions concerning manoeuvres and movements are given in order of probability, as long as the driver has been notified on the course that the microcomputer considers most probable:

e.g. * FOR RIGHT TURN (speed, etc. instructions)
* FOR LEFT TURN (instructions)
* FOR STRAIGHT COURSE (instructions)

Thus, in any case the driver is supported by the guidance service, on manoeuvres which he/she should carry out, that is either the followed route is predetermined or the microcomputer considers it to be probable. From the state-of-the-art systems there is none that provides such a service.

The instructions provided to the driver, are transmitted by the three communication methods between microcomputer and driver, i.e.:

- By audio means [Chapter d - Par. (41)]
- By visual means [Chapter a - Par. (3)]
- By the sense of touch device [Greek Patent Application No. 910100339/91]

In the following chapters, whenever driver's information is mentioned, all above three methods are implied, even if they are not specified. The advantages of the above methods are mentioned in the respective chapter.

In order to provide the instructions of the guidance service, the microcomputer takes into consideration:

(1) The vehicle's exact position at any instant [Par. (35)].
(2) The road network data (Chapter b).

Depending on those two data for course estimated or not, the following instructions and warnings are provided:

a) Warnings are provided to the driver by the aforementioned methods on any occurence that influences the current course and requires a corrective manoeuvre. More specifically:

* The driver is warned about topographic data that require corrective manoeuvres, specifically for:

■ Street narrowing (for reducing speed)
■ Street narrows from right or left (if the driver follows right or left lane, he/she should proceed to another one)
■ Road surface quality (for driver's attention if it is of bad quality)
■ Hazardous transversal or longitudinal road inclination (speed reduction is reccomended)
■ Road curvature (speed reduction is reccomended)

* The driver is warned for the road network traffic signs, such as:

■ STOP (for progressive speed reduction until complete immobilisation)
■ SPEED LIMIT (e.g. 50 Km/hour) (for complying thereto)
■ PROHIBITION OF RIGHT TURN (to avoid turning)
■ SLOW (for complying with the traffic sign and reduce speed) etc.
■ APPROACH TO A RAILWAY (for increased attention)

* The driver is warned about areas or buildings to the right or left of the road, that influence the course of the

vehicle, such as:

- SLOW - SCHOOL
- ATTENTION - FACTORY EXIT
- HOSPITAL - SLOW, etc.

b) Warning provided to the driver on manoeuvres and movements required upon approach at a node for vehicle's course continuation. Thus the driver is warned of:

* The lane to be followed for e.g. turning left or going straight ahead.
* The speed for approaching to a node e.g. speed reduction for a sharp turn.
* Other manoeuvres for approaching to the node (e.g. special manoeuvres for complex multi-levelled nodes).
* The traffic signs or special requirements of the nodes.

The driver, as aforementioned, is warned by audio or visual means or by the sense of touch device. Special methods and guidance devices are also provided for manoeuvres and movements concerning the course to be followed that guarantee the most effective warning for the most appropriate manoeuvre that the driver should make.

41. Device for Acoustic Data and Information transmission from the Microcomputer to the Driver

A loud speaker announces, in a language comprehensible by the driver, the instructions and/or information concerning guidance and control of the driving conditions. It also transmits simple acoustic tones that correspond to a certain driver's support operation. Indicatively, the transmission of a tone e.g. BEEP, during vehicle's passage from a crossroad or during turning. If the tone is not transmitted at the moment of vehicle's passage, the driver may rectify the error of the position estimation, during its passage

from the next crossroad, by using an appropriate key. More details are mentioned in the functions of the position estimation method [Par. (38)].

42. Keyboard

It is used for the transmission of data from the driver or the passengers to the microcomputer. It is a conventional keyboard that may be used both by the driver of the immobilised vehicle and by the passengers for communicating with the in-vehicle microcomputer.

43. Guidance by the use of Blinkers

During this service two groups of blinkers are used for providing instructions to the driver, each one placed to the left and right of the driver, in a position that is covered not by the direct but by the extended angular field of sight. Such positions are e.g. on the instruments board, to the left and right of the steering wheel. The activation method of the blinkers signifies the guidance instructions provided to the driver [Figure (76)]. The main advantage of such a method of providing instructions is that the driver's attention is not distracted from the road and it has an immediate communication ability. The driver immediately understands, almost without any special mental effort, the guidance instruction. Another serious advantage is the simplicity of its operation (it does not require, for example, registration of characters, voice synthesis, symbols etc.) which constitutes this service handy and inexpensive. Another advantage is the variety of combinations and, therefore, instructions and commands given by the two groups of blinkers. Examples of such a service embodiment are the following:

<u>TURN RIGHT</u>: The right group of blinkers are turned on in a sequence of 1 - 2 - 3 - 4 - 1 - 2 - 3 - 4. The speed of each light's turning on and off is accelerated as the vehicle

approaches the turning point.

TURN LEFT: A sequence corresponding to the one of the right group occurs i.e. 4 – 3– 2 – 1 – 4 – 3 – 2 – 1.

COMPULSORY STOP: Both groups of blinkers are simultaneously turned on and off.

SPEED REDUCTION: Two of each group's blinkers are turned on and off,

and so forth.

In another embodiment, each blinker displays a different colour (e.g. green, red, blue, white etc.). It is thus provided the possibility of additional guidance combinations and commands. The technology of blinkers activation is considered to be known to the experts (e.g. LED) and it is not stated herein.

44. Echo-Formation

In a previous chapter, the method of nodes registration in the memory unit as stated. According to this service for the nodes schematical representation, a name and form are used that do not refer to the whole image that the node presents, e.g. when it is examined from some height or schematically, but to the image and form that the driver sees upon entering the node. An example of such name difference appears in Figure (77), where a cross-shaped node appears while for the driver forms a type Π (pi) image or reversed Π depending on the followed direction. A second example appears in Figure (78). It is understood that the image (Echo-formation) and therefore the code name and form that will be given to the node, depend on the direction of the driver's entrance to the node. A node for example of trumpet type, has numerous names, depending on the direction that the driver enters the node. The driver's notification from the processing system, optically, acoustically or by touching, relatively to the image (echo-formation) of the oncoming node provides the driver the capability to confirm his position optically.

45. Course Indicator

A supporting service which the method offers for the accurate driver guidance, where the driver is notified acoustically, visually or by the touch device for the proper steering wheel turning angle at each course location. The driver needs guidance about the proper steering wheel angle in the following cases:

(a) When during the prescribed course he does not know where he should turn. That occurs mostly when he is about to select a road in a complicated intersection where the road edges do not have a concrete geometrical form or width.
(b) When he does not know exactly when he must begin to turn. That usually occurs at squares, wide streets, etc.
(c) When he deviates from the road axis, due to, e.g. obstacles, and needs to return at the same road axis. That occurs mostly when the following cases exist:

(1) Turn at the beginning of 2-3 roads where there is doubt about which is the correct one.
(2) At squares exits where the roads are close and the directions are difficult to be understood.
(3) At cases where there is a doubt about the lane selection.
(4) At garages, parking, yards, unmapped areas where he does not know how to exit.
(5) Mostly at cases with minimum visibility, dark, fog, rain, obstruction from large vehicles, bad or lack of road traffic signs, etc.

If each vehicle deviation from the course axis, does not exceed certain value, then it is considered that the vehicle does not deviate from its course. But the accurate position of the vehicle is required by the driver when he is about to be supplied with information for the accurate angle that the steering wheel must have, when there is doubt. So, the course indicator method monitors, for example, the

overtaking of an obstacle before a turn, and identifying the deviation from the course axis, shows continuously the necessary turn of the steering wheel which is required in order to enter the turn.

Consequently the course indicator performs consequently the following sub-services:

(a) Continuous course specification for vehicle restoration to the initial prescribed course, whenever there is a deviation from it.
(b) Continuous driver guidance from the exact position of the vehicle at any moment towards the position that the initially prescribed course predicts.
(c) Continuous, dynamic (with respect to the road network data) guidance that corresponds completely to the topographic data, at each moment.
(d) Specification of the course and guidance for reverse movement of the vehicle. In case that the vehicle moves backwards, the reverse course is taken under consideration for the restoration of the vehicle at the prescribed course axis. Naturally, the restoration directions of the vehicle include reverse or forward movement of the vehicle and combination of them. The road network data which are stored in the memory unit are extensively described in chapter b. From these elements, the topographic data of the road network are mostly used:

* Road surface width
* Disposed traffic lanes
* Transversal slope
* Longitudinal slope
* Road surface curvature

The road curvature (or curvature radius) per course meter, is the most interesting among those data, because the course indicator, since it prescribes the directional wheels transversal angle, actually prescribes the curvature radius

of the vehicle trajectory (Figure 79). Actually, the curvature radius of the vehicle trajectory is a function of the steering wheel turning angle.

$\rho = f\ (\varphi)$ or $\varkappa = 1/\rho = f_1\ (\varphi)$

For the determination of this function, geometrical data of the vehicle that uses the proposed method are required. A tabular representation of the curvature $\varkappa$ or the curvature radius of the vehicle trajectory versus the steering wheel turning angle, is given in Table (9).

The function of this method is schematically indicated in Figure (80), where the real position of the vehicle on the road network is shown, as it is determined by methods and devices. The trajectory that the vehicle must follow is shown by the broken line. The indicated steering wheel's turning angle, is the one that corresponds to the trajectory radius of curvature, which restores the vehicle to the prescribed course. The turning angle is changed as the vehicle approaches the prescribed course and its trajectory tends to coincide with the prescribed trajectory (Figure 80). On the basis of this embodiment, the following supporting sub-services are provided.

1) Automatic Guidance Service

The microcomputer knows the position of the vehicle at any point and so it issues its decisions in relation to:

* the cartesian coordinates of the vehicle
* the direction of the vehicle's axis
* the proper turn of the steering wheel

The Course Indicator's method takes under consideration all the above, judges (if of course the vehicle's axis deviates from the course axis) and makes a short return routing.

STEER. WHEEL TURN Φ RIGHT IN (°)	COURSE CURVATURE (ϰ)(m^{-1})	CURVATURE RADIUS (m)ρ (ϰ=1/ρ)	STEER. WHEEL TURN Φ LEFT IN (°)	COURSE CURVATURE (ϰ=1/ρ)	CURVATURE RADIUS ρ(ϰ=1/ρ)
+ 0		∞	- 0		- ∞
+ 10		1050	- 10		-1050
+ 20		450	- 20		- 450
+ 40		350	- 40		- 350
+ 80		200	- 80		- 200
+ 120		105	- 120		- 105
+ 180		58	- 180		- 58
+ 270		45	- 270		- 45
+ 360		35	- 360		- 35
+ 540		29	- 540		- 29
+ 720		22	- 720		- 22
+1000	0.00	18	-1000	0.00	- 18
+1180	0.08	13	-1180	- 0.08	- 13
+1360	0.1	10	-1360	- 0.1	- 10
+1540	0.13	7	-1540	- 0.13	- 7
+1720	0.1	5	-1720	- 0.2	- 5
+2000	0.337	3	-2000	- 0.337	- 3

TABLE (9) - RELATION BETWEEN STEERING WHEEL TURNING ANGLE AND CURVATURE RADIUS OF VEHICLE COURSE

So, the Course Indicator is:

a) An automatic routing for return to the course axis in case of deviation with simultaneous continuous indication.

b) A continuous confirmation that the vehicle is at the correct course with simultaneous continuous indication for monitoring of this course.

Also, when the vehicle is immovable then the Course Indicator's indication depends always on the turning of the steering wheel. The drivers usually after a braking, maneuver, parking etc. have forgotten the angle of the steering wheel and upon ignition they are faced with hazardous situations. In this case the Course Indicator gives the correct angle of the turn of the steering wheel, depending on each case, before the vehicle starts moving. So, if for some reason, the driver interrupted the vehicle's course, the Course Indicator helps him correct the steering wheel's angle, even when the vehicle is immobilised.

The indication of the Course Indicator is redefined frequently, in proportion to the travelled length and time, so that its indications are always timely and corresponding to the dynamic evolution of the course. The time between the sampling indications from the odometer, the steering wheel sensor etc. is defined from the driver's reaction time, so that large deviation from the previous indication is avoided. Due to the fact that the Course Indicator is mostly used during turning, the data processing system performs more frequent sample checkings at turns, according to the vehicle's position.

2) Selection of Course's Criteria

The course specification by the Course Indicator (immediate action) differs from the one of the main routing. It is

activated each time there is a deviation of the vehicle's axis from the wavy course's axis. Also, at turns it helps the restoration of the vehicle at the proper trajectory. For the determination of the best course for the restoration routing, the system needs to know or calculate at which point of the wavy course it must provide the restoration indication. When for example, the vehicle overtakes another vehicle in a straight road, then the Course Indicator should normally show the need for returning to the lane, since it cannot determine whether the driver is interested on the Course Indicator information. In that case it shows restoration. The direction of the restoration varies in proportion to the vehicle's speed. Specifically, at high vehicle speed the entrance to the previous lane must be at the proper slope. But as long as the driver does not obey to the indication of the Course Indicator, after a while the system disregards it and shows straight, thus accepting the particular course as correct and basis for further interpretation of any deviation.

By the acceptance of the Course Indicator's initial position as correct, the driver accepts that, during the main part of its course, the vehicle is properly placed on the road with respect to x' and y'. The objective of the Course Indicator is not to check to vehicle's course versus the prescribed course but the position of the vehicle's front part versus the axis of the prescribed course which it considers to be correct. It is understood that the driver has placed the vehicle on the proper lane, therefore when the Course Indicator indicates right turn, it considers that the vehicle is already placed on the right lane. In case the vehicle is in limited area and moves at low speed, as for example on a circular square after overtaking another vehicle, the calculated distance is very important. For that reason the shortest possible return to the wavy course's axis is calculated.

3) Positive and Negative Elasticity of the Course

Indicator

If the vehicle's identification on the road surface is not correct, then the Course Indicator will provide incorrect indications. If for example the odometer shows a turn before the real one, then the Course Indicator, which considers the odometer's indications correct, will also give indications in the wrong place. The same will happen if the odometer considers the turn after the real one. The Course Indicator, in order to be useful, should function at the right point only and it therefore requires correct identification.

Hence, when it starts indicating before the turn, the error becomes easily perceptible by the driver, since there is no road to turn. Since the driver does not obey, the Course Indicator stops providing indications after a few meters, and is waiting for the driver's next action. When the driver starts turning and the system's calculations show that the vehicle crosses the limits of the sidewalk, the Course Indicator is reactivated, takes under consideration the correct travelled distance and indicates from that point after.

At the second case, when the odometer shows a turn after the real one, the following happens:

The driver does not exclusively rely on the Course Indicator's instructions, but mostly on his judgement regarding the choice of the corner where he must turn, and the Course Indicator starts the indications considering as correct the travelled distance. With the Course Indicator's elasticity to accept the turn after or before the odometer's indications, the correct identification is achieved even before the Vehicle's Position Estimation Service because the latter will decide only when the turning is completed. But the Course Indicator accepts it as correct earlier and continuously assists with its indications for the correct

execution of the turn. Of course, the Vehicle's Position Estimation Service has the final word for the identification but for the majority of the turns the Course Indicator assists significantly and it eliminates the mistakes from bad selection of the roads at crossroads, squares etc.

METHODS OF INDICATION

On the screen, an indicator and a graded straight line or curve appear [Figure (3)]. When a deviation from the road's axis is identified, the driver is notified as follows:

Optically: The needle shows the right or left deviation and where it exists. Its restoration to the centre means the correct course.

Acoustically: The amount of the degrees that the driver must turn the steering wheel is stated by voice, as well as the direction that the vehicle should have.

By touching: The touch keys are activated in a circle so that they show the angle that the steering wheel must be rotated. Activation of keys clockwise show right turn and vice versa.

The correct execution of the indication by the driver, restores the needle at the indication's centre. In case of improper execution, the indication of the needle remains at the corresponding new position, and the driver is notified acoustically, regarding the correct execution. In case that a backwards course is required, then the needle shows backwards of the centre and the acoustic notification is "Backwards". After the end of the backwards course, the needle shows again forward and the acoustic notification becomes "Forward".

46. Inscription of Road Names and Crossroads

According to this service, the street names which the

vehicle passes are shown on the system's display, as well as the names of the transversal streets which are encountered, whereas during another embodiment the roads parallel to the one that the vehicle moves on are also displayed.

This service is especially useful for the drivers' orientation during the course through urban centers. It also serves special professional groups, such as postmen, merchandise distributors, taxi drivers etc., who use the classic addresses and road names. It is also useful for travelling through an unknown city or urban centre, having the destination's address as the only data. The service combined with a classic map, escorts every routing service and vehicle's position identification.

47. Guidance through Areas of Dense Crossroads (close alley-ways)

This guidance service is particularly useful in areas of many crossroads (i.e. densely populated urban centers) where the vehicle must execute repeated maneuvers (i.e. successive right and left turns) and the successive directions from the processing system do not suffice and do not always allow for sufficient time for compliance by the driver. According to this service, guidance instructions are supplied to the driver, concerning not only the immediate operation, which is required, but also the next maneuvers that must be performed along with vehicle's position identification from the start. Example of this service's embodiment is:

- RIGHT TURN-STRAIGHT TWO ALLEY-WAYS-LEFT TURN
- STRAIGHT-RIGHT TURN-LEFT TURN IMMEDIATELY etc.

48. Proper Lane Notification (approaching at node)

The vehicle's placement and movement on the proper lane constitutes a basic presupposition for accurately following a predetermined course. In many cases some maneuver is

prohibited, if the vehicle does not move on the proper lane or consists a hazard to the vehicle's and other vehicles' safety.

The usual guidance systems do not include any special notification for the proper lane but they simply inform the driver for the next direction that he/she must follow. The direction that must be followed, is considered sufficient information for the driver, for placement of his vehicle on the proper lane (i.e. they notify the driver for RIGHT TURN). After this announcement it is considered that the driver will place his/her vehicle on the right lane. The disadvantages and problems, which are created due to the lack of indication of the proper lane are many. The following are reported:

(a) In case of multi-level nodes, every turn requires the attendance of a particular lane. In this case, the indication of the direction (i.e. left turn) is without value, since the driver does not know the lane that directs to the left. Figure (81) shows the above mentioned case, where for any followed course, knowledge of the corresponding lane is required. In Figure (81) it is clearly shown that for courses (I) and (II) the lanes A direct to the right, while the nearest lanes B direct to the left.

(b) When, after a right turn, follows a left one, if the driver is not placed on the proper lane, when executing the first turn he cannot execute the second turn. An example is shown in figure (82) where it is indicated that the vehicle, coming out of position A, must be directed, to lane III. If it is not notified and follows lane I, then it cannot execute a turn towards B.

(c) Finally, the lane where the vehicle moves on is important in case the road is divided and each lane leads to a different direction. Such cases appear often at the

interstate and interurban network, where each lane leads to a different city or even country.

The basic disadvantage of the methods which have been examined, is that they do not contain, in the data stored in the memory unit, elements for the available lanes of every part of the road network.

On the contrary, in the present method, the lanes constitute part of the road network. Consequently, with the present method information concerning the lanes and the proper lane where the vehicle must be placed are provided. The driver is notified, not only for the next course that he must follow, but also for the next two maneuvers that he must execute, e.g. RIGHT TURN-STRAIGHT-LEFT TURN. Hence, from the sequence of course the system determines the proper placing of the vehicle [Figure (82)].

49. Driver's Warning for Next or after-the-next Signs.

This guidance service is provided by the present method only and it concerns the notification (optically, acoustically or by touching) of the driver for modification of the vehicle's speed and position, not only as to the signs that follow immediately after, but also for the after-the-next signs that will be encountered after the following one. An example of notification for the after-the-next signs appears in Figure (83). The vehicle moves on the road network and meets a priority sign and a high speed limit. However, the microcomputer notifies the drivers for speed reduction because it takes under consideration the unattended railroad crossing that will be encountered after the first two signs.

For every sign that follows, the table of minimum distance which the driver needs in order to conform with the sign, is taken under consideration (i.e. immobilisation of the vehicle) [Chapter e - para (85)]. The driver is notified

about the sign which requires certain maneuvers for compliance. Figure (83) shows the advantage of this service. If the drivers comply to the next two signs (I) and (II), they will not be able to stop at the railroad crossing.

50. Approach to a multi-branch node (imaginary)

An imaginary node is placed before the traffic or the multi-branch node, at a distance that depends on the maximum allowed speed in the previous part of the course.

That imaginary node, is registered in the memory unit [Chapter b - para (10)]. The distance before the real traffic or the multi-branch node is selected such that, based on the maximum allowed speed, the driver be allowed to easily change lanes. In figure (84) the imaginary node is shown in position A-A, before the multi-branch node.

The driver is notified upon passing, for the course that he/she must follow, by the number of lane I or II or III or IV [Figure (84)]. The notification can be acoustic, e.g. FOLLOW SECOND LANE FROM RIGHT, or by the touch device. For the visual notification, according to one embodiment the following indicative arrangement is provided:

On the dashboard, a lamp system is placed, e.g. 10 in series. Activation of one lamp means placing of the vehicle on the first right lane. Activation of two lamps means placing of the vehicle on the second right lane, etc. The activation of the lamps is interrupted (blinkers) for warning the driver to enter the proper lane. The acceleration of the blinking rate ends in continuous activation, when the driver "must" be on the indicated lane. The activation of the lamps is optionally escorted by acoustic continuous or interrupted signal.

A great advantage of the present method, is the sense of

safety, that provides the driver, regarding the course which he/she must follow. The driver is attention for the signs which are indicative of the course is no longer required. Frequently, accidents are caused by careless lane change.

51. Position Estimation and Guidance to Multi-Levelled Areas

According to this service, the vehicle's position is estimated in multi-levelled areas, as e.g. multi-story parking, multi-level nodes etc. In these areas, for the usual position estimation of the state-of-the-art methods, there is a problem of identification of the level where the vehicle moves on. In the special case of unlevelled nodes a guidance problem appears if the unlevelness and the direction of the vehicle's movement are not specified.

This method foresees the following ways of identifying the level where the vehicle is found or towards which it moves.

(a) Use of transmitters: On each level a transmitter is placed, and its transmitted signal code reveals the level on which it is placed. The transmitted signal's reception reveals the vehicle's position.

(b) Tracking of ascending or descending course: Usually, in multi-story areas, ramps of definite geometry are available for transition from one lever to another, e.g. in multi-story parking, ramps of spiral circular or of other type are used. Also in unlevelled nodes, circular auxiliary roads are used. If in the area's neighborhood, a vehicle movement is identified in a trajectory that corresponds to the ramps geometry (e.g. a circular trajectory of constant radius equal to the ramp's radius), it constitutes proof that the vehicle moves towards a different level. Registration of e.g. the complete circles that it performs, corresponds to the levels on which it goes up or down.

(c) Comparison of the initial and final position: If the vehicle moves in an area where a going up or down ramp is foreseen from the mapping, and after the completion of a close routing is found that the vehicle is on the same point where it started from, it is proof that the vehicle ascended to another level.

e. PROTECTION (by use of Sensors only)

(1) Two Sensors (Odometer-Steering Wheel Sensor)

52. Warning for Deviation from Vehicle's Course

According to this service, the driver is notified optically, acoustically or by touching, for any deviation of his course. The ways of deviation determination are stated in Chapter d - Para (26) - (31). According to this service, deviation of the order of ±1.5m is announced, which approximately corresponds to the vehicle's lane change. In this case, the visual signal (e.g. blinker) or the acoustic signal (e.g. buzzer) or the touch signal is indicative of the following possible situations:

(a) Right or left lane change and declaration of the lane that the vehicle moves. In this case, if the lane change has been done deliberately, the driver is notified that the system acknowledged the lane change and the guidance services are adjusted for the new position of the vehicle.

(b) If the lane change was not done deliberately but by mistake, or due to lack of attention, the signal to the driver has the form of a warning. This characteristic is especially useful at roads of two-way traffic, whereas the vehicle upon changing lane enters in the opposite direction of traffic, when the optical, acoustical or by touching signal warns the driver.

(c) Sudden change of course by ±1.5m. In case a sudden

change is monitored, it is considered as an indication of extraordinary event (e.g. obstacle on the road, loss of control, bad maneuver etc.) and the driver is alerted with proper instructions.

53. Warning for Deviation from Course Main Axis

According to this service the driver is notified or the protection systems are activated, e.g. immediate immobilisation of the vehicle if its trajectory deviates slightly or more from the predetermined course. The deviation from the predetermined course is determined by the following facts:

(a) It is not foreseen from the road network data, such as the case of turns.
(b) It is continuous and not interrupted, such as the case of lane change.
(c) It is progressive and not sudden, such as the case of the vehicle's entrance in an unmapped area.

Figure (85) describes the case of deviation from the track in comparison to other cases (e.g. turn, lane change). The software methods of identifying the deviation are similar to the methods which are described above. The notification for deviation from the vehicle's track is a very useful protection service, since the system searches and warns the driver at the early stages of an accident. Actually, deviation from the track indicates distraction of the driver's attention, e.g. loss of conscience, sleep etc.). Hence, long before the deviation develops e.g. to a collision, entrance to the opposite traffic lane, exit from the road, fall in a ditch etc., the driver is warned or the protection systems are activated. As it was stated, the fact that the system searches at the the early stages of a possible hazard and not when it becomes obvious, constitutes a feature of superiority of the present method.

54. Driver's Physical Condition Check

A service for the driver's assistance according to which the driver's physical condition is checked using the vehicle's movement data, that is if he is in state of drunkenness, sleep, limited attention etc., which is characterised by the processing by the microcomputer of the vehicle's movement data only (without reference to the data that have already been registered in the data base), their comparison to the data which result during driving by a healthy person (standard data), and interpretation of every deviation from the standard data at corresponding deviation of the driver's behavior from the normal healthy behavior.

From the systems examined in the State of the Art (Chapter B) it is not stated anywhere checking of the driver's physical condition by any proposed guidance or assistance systems. One such deficiency is considered significant, mainly for the following reason:

When the driver is in healthy condition and alert, he is less in need of the protection, checking or guidance system. On the contrary, when the driver's physical condition is not good, e.g. when he is in state of drunkenness, sleepiness, emotional stress etc., he is in great need of the guidance, checking and protection that the present system provides. In this case the other drivers as well are in need of protection from the said driver. Especially for long distance drivers or trips of many hours, the aggravation of their physical condition (e.g. lethargy or drowsiness) during the trip happens unscrupulously. In this case, checkings are mainly required and warnings concerning his/her physical condition, since there can be no other assistance.

It is known that during a vehicle's normal driving, the driver's operations are never smooth and continuous but they always present deviations from a constant value. These

deviations consist of minor corrections of the vehicle's course and speed. Practically, even during the straight movement of the vehicle, the driver continuously rotates the steering wheel alternately around an average value, while the vehicle's course in a wavy motion around an intermediate track. Furthermore, the driver continuously increases and decreases the speed, especially during his movement in urban centers, by successive activation of the acceleration pedal or the brakes.

These continuous changes, in the case of a healthy, alert person present a fixed deviation from the intermediate course and speed of the vehicle. This intermediate deviation is measured and entered into the data base, and constitutes the standard for comparison, which is called the standard deviation for reference of course or speed. Therefore, if during the vehicle's course the deviations due to the corrective maneuvers are measured and are compared to the reference standard deviation, several conclusions are drawn concerning the driver's physical condition, e.g. lack of corrective movements, that is lack of deviation, reveals sleepy condition. Also deviations larger than the reference standard deviation reveal state of strong emotional stress.

Naturally, the vehicle's data processing system does not state the driver's physical condition during checking of the deviation from the reference standard deviation, but mainly by comparison, it checks and protects the driver of the specific vehicle and the nearby moving drivers.

The advantages of this service are:

(a) Its application is very simple. Only two devices are required, e.g. odometer [Chapter a - Para (4)] and sensor of the directional wheels transversal angle [Chapter a - Para (5)] for drawing conclusions by the data processing system.

(b) It is effective and accurate because the consequences

of the driver's physical condition on the course and speed of the vehicle are directly checked, therefore there is no chance of subjective mistake at the direct checking of the driver. More simply, as long as the vehicle doesn't move properly, something must be happening to the driver. On the contrary if the driver is not completely well but he is under complete control of the vehicle, then there is no problem.

(c) The vehicle's course and speed are checked at any instant, therefore the driver attendance is continuous. This is especially useful e.g. during long trips.

(d) It has been observed that many accidents are caused by drivers under influence of alcohol, as well as under state of emotional stress, where driving is used as means of loosening, therefore the present service more than any other contributes to the drivers' protection from accidents.

During driving, the driver tries to keep the vehicle in the middle of the lane or the one way street or in parallel course to the road's axis. In order to succeed in it he/she continuously performs minor movements of the steering wheel to the right or left. Furthermore, he continuously increases and decreases the vehicle's speed in order to keep it below a safe value (the minor corrections of the speed are especially strong in turns or during movement on roads with other vehicles' presence). The mechanism of these corrective movements is the following:

During the vehicle's movement, the experienced driver soon realises minor deviations of the vehicle from the theoretical course and speed and he properly corrects the course. The sooner the position and speed are corrected, the smaller the minor corrections are. But there is always a limit of the timely corrections performance, which is looseness of the directional system mechanical parts and the usual operation of the drivers' reflexes (e.g. a certain

time lag exists between realisation of the deviation by the driver's brain and the reflective course correction). Furthermore, more intense corrective maneuvers are required directional system for a vehicle with intense looseness problems at the directional system.

From the correction mechanism the following conclusion is drawn i.e. for the checking of the driver's physical condition, the reaction time, which is less in case of emotional stress state and larger in case of state of drunkenness, sleepiness etc. is the most important factor. Hence, a certain number of direction corrections and a certain number of speed alternations in the time unit, correspond to the driver's normal condition.

This is embodied as follows:

The indications of the directional wheels' sensor are checked. The sampling of the device is high enough and significantly larger than the alternations of the minor corrections. Graphically, the sampling during the vehicle's movement in a course, appears in figure (86a). A similar graph appears for the case of the speed increase and decrease, where the alternations mark accelerations or decelerations of the vehicle. In this figure a sampling by a period of time Δt (e.g. every 0.1 sec) is marked and the successive alternations from the previous value are checked for a certain period of time, which constitutes the constant time reference. The alternations are examined in comparison to the previous sampling value, while the alternations' number is examined for a period of time To.

Figure (86a) shows a normal sampling, while figures (86b), (86c) and (86d) show a hyperactive state, medium loss of control and sleepy condition successively. Figure (86) is a synthesis of all the previous figures for the convenient comparison of the curve with the "characteristic" behavior curves. The reference time To is e.g. 1 sec and contains

e.g. 7 samplings. Overlapping of the sampling times To is possible. The alternations, positive and negative, are marked with + or - while the lack of alternation with a simple circle. Upon comparison of statistic results, the most probable alternations number appears for alert and healthy condition, e.g. 5 alternations + or - per time To = 5 sec. If the number of alternations is higher, e.g. 8 alternations + or -, it indicates condition of increased alertness. If there are less alternations + or - or none, it indicates condition of decreased attention or sleep.

According to another embodiment, besides the alternations + or -, their intensity, ranked is also checked, which depends on the difference between two successive indications, for transaction of other conclusions concerning the state of alertness. In case the microcomputer, at any embodiment, identifies deviation from the normal course, it notifies the driver acoustically, visually or by the touching device or notifies the other drivers acoustically or by the transmitter of attention signal (electronic horn) [Chapter e- Para (79)] and finally (if it is foreseen) interferes with the directional system and e.g. immobilises the vehicle.

55. Service for Driver's Artificial Awakening

According to this service, the driver requests from the microcomputer its continuous alertness and visual, acoustic or by touching notification, while the microcomputer "requires" from the driver the execution of certain maneuvers at the unit of time (e.g. course correction maneuvers) and if these maneuvers are not executed, then the driver is either notified or annoyed. According to a variation of this service, the microcomputer automatically activates the awakening service when it identifies bad physical condition of the driver [para (54)].

From all the examined systems in Chapter B, none foresees

service to the driver for improvement of his physical condition or his awakening in order to avoid accidents. Actually, in the other systems, the checking and protection from the driver's bad physical condition is completely missing. In common practice, the only alternative that the driver has, is the interruption of the course and his resting, so that he/she can normally return to his/her previous healthy alert condition. However, there are cases where the trip's conditions require a continuous awakening. These conditions are:

* During night driving, when the danger of sleepiness is greater.
* During the vehicle's movement in environment with high temperature (e.g. summer).
* During the vehicle's movement for a long time at large distances (because of physical fatigue).
* During the vehicle's movement at strong light (e.g. summer or snow-covered areas) because of visual fatigue.
* During driving after lunch or physical fatigue (because of bad blood circulation in the brain etc.).

In these cases the driver needs a continuous artificial awakening so that the partially missing awakening be restored. Two ways for the service activation are foreseen:

(a) When the driver realises some fatigue or absent mindness during driving (which can arise from the above mentioned reasons, or generally from bad physical condition), requests from the vehicle's microcomputer the present awakening service.

(b) The microcomputer automatically activates this service in the following cases:

* During night driving, (every trip's time is in reference to the microcomputer's chronometer) and especially during driving between midnight and morning hours.

* After certain period of time (e.g. 2 hrs of continuous driving).
* At the highways of the first level [Chapter c, para (21)] or generally at the highways of high frequency of accidents [Chapter e, para (83)].
* In case the service of "driver's physical condition check" [para (54)], shows driving beyond the reference standards.

The service consists of the following:

The execution by the driver of a certain minimum number of manoeuvres', in proportion to the seriousness of the condition is requested visually, acoustically or by the touching device. The maneuvers that may be requested are these for which an operation checking from the microcomputer is foreseen, so that it can be determined whether the driver executes the requested maneuvers. Such commands are:

* Use of the acoustical warning system (horn) in a frequency of e.g. once every 30 sec.
* Minor corrections of the vehicle's direction and course (e.g. 5 every 20 sec).
* Blinking of the hazard lights (4 lights at the same time) e.g. once every 30 sec.
* Use of the brakes (lightly) or light reduction of speed e.g. once every min at least.

This way, the driver is continuously checked whether he/she follows the required directions or he/she is alert. If some maneuver is not executed, an e.g. alerting sound or flash is transmitted. Basically it is an awakening method which forces the driver to stretch his attention, for small periods of time, in compliance to the indications.

1. The method is safe because a check of the driver's condition takes place at regular intervals.
2. It is simple. Basically, some device is checked upon

regular periods of time from the data processing system of the vehicle.

3. It is effective, because it aims at a corrective process which positively irritates the driver.

4. By use of the touching device or the screen only, the passengers are not disturbed (e.g. when the driver conforms to the corrective process, nothing is heard).

56. Service for the Protection against Spinning

A service aiming at the driver's protection against spinning of a vehicle at high speed, and supply of instructions for the vehicle's restoration at the straight or regular track. With the term SPINNING, the wavy course that a vehicle performs during an obstacle avoidance maneuver during high speed travelling, is indicated [Figure (87)]. An analysis of the vehicle's motion during this phenomenon shows a rotation with an angular velocity ω, which can be analysed in two rotations:

- Rotation of the vehicle's center of mass G with angular velocity ω_1, around a rotation centre which is defined by the wheels angle of turn Θ, consequently from the steering wheel's angle of turn φ [Chapter d - Para (24)].

- Rotation of the vehicle around the centre of mass G with angular velocity ω_2.

The forces which are developed (centrifugal due to ω_1 and inertial forces due to angular acceleration ω') are balanced by the wheel friction forces when the wheels are in contact with the ground. In the chapter for maximum turning speed [Chapter e - Para (67)], the method of calculation of the centrifugal force from the mass, speed and curvature radius of the turn has been analysed and the vehicle's angular acceleration ω' has been computed, as a function of the vehicle's geometric data, position of the centre of mass, velocity and angle of wheels' transversal angle Θ (appendix

II).

$$\frac{d\omega}{dt} = \frac{dU}{dt}\frac{\tan\theta}{M} + \frac{U}{M}\frac{\theta'}{\cos^2\theta} - \frac{b}{M}\frac{\theta''}{\cos^2\theta+(b/M)^2\sin^2\theta}$$

$$-\frac{b}{M}(\theta')^2\frac{2\sin\theta\cos\theta\,[1-(b/M)^2]}{[\cos^2\theta+(b/M)^2\sin^2\theta]^2}$$

where M vehicle's wheel base and
b distance of the centre of mass from the rear axle.

The center of mass' distance "is estimated" approximately by the processing system e.g. moving the centre of mass G backwards as function of the vehicle's weight, which is found by the method of Chapter e - Para (61). For the case of a towed vehicle, a different than the above formula applies.

When the forces that have been already mentioned exceed the maximum friction force for each wheel, then the wheels lose contact with the ground and the vehicle slips (the maximum friction factor μ_{max} depends on the road surface type, the weather, the tires wear etc., and it is automatically calculated by the system). In this case the car manufacturers recommend minor corrective movements, without sudden brakings, or accelerations and without violent movements of the directional system, naturally depending on the vehicle type, the suspension, the driver's experience etc.

The almost uncontrolled vehicle movement continuous until its speed is reduced so that at some point the wheels stop slipping and the vehicle is found again at the static friction force range. For the normal restoration of the

vehicle in its course, it is required that it decelerates by the friction power of its rear wheels only, which are behind the vehicle's centre of mass. Hence, the vehicle will tend to move in the direction of its longitudinal axis, which is desired. During its spinning in order to brake by the rear wheels only, the front wheels must always point at the direction of motion of the vehicle, so that they practically do not resist the motion of the vehicle at the direction of the front part. This practically means monitoring of the front part's movement and turning of the steering wheel towards the direction of its course (which is a combination of the motion of the centre of mass and the vehicle's rotation).

The difficulty that the driver encounters, is due to the fact that he/she participates to the vehicle's rotation and therefore, he/she cannot (especially due to inexperience) determine the resultant vehicle's course, so that he/she can turn properly the front wheels. A characteristic of the present service is the fact that the system automatically tracks the spinning process of the vehicle and in every stage it notifies the driver about the required movements or corrective maneuvers.

From examination of all the guidance or assistance systems, none was found to contain assistance service during vehicle's spinning. For tracking of the vehicle's spinning phenomenon, the odometer's and the wheels transversal angle measuring device's indications are used, as well as the road network data (road slip factor, road transversal slope etc.). The processing system calculates the forces applied on the wheels and from their sudden increase, beyond a maximum value, it identifies the beginning of the phenomenon. Unfortunately, the prompt notification of the driver is not possible just before the spinning begins, since the phenomenon depends on unpredicted events (e.g. an obstacle on the road, maneuver for collision avoidance etc.). But the handling of the situation is possible

afterwards by supplying to the driver certain instructions, so that he/she will not lose control of the vehicle due to wrong reaction.

The handling of the situation naturally depends on the vehicle's type, the front or rear wheel drive, the suspension type, etc., but the manufacturers agree that only with minor corrective movements of the steering wheel and the break, the driver can keep the vehicle under control, turning always the front wheels towards the direction of the centre of mass G motion (reversed steering wheel).

At the beginning of spinning, a direction to the driver is provided, not to apply the brake heavily and to turn the wheels towards the same direction that they are rotated. This can be explained as follows:

For stable equilibrium of the directional wheels (to return by themselves at the straight line) their vertical axis of rotation passes in front of the horizontal axis of rotation, and therefore by the point of contact of the wheels to the ground. Hence, when the vehicle rotates e.g. clockwise, the wheels turn also clockwise relative to the vehicle [Figure (88)]. But since the vehicle must follow the movement of the centre of mass, and as mentioned already the wheels must not prevent the vehicle motion, a direction is supplied to the driver to turn the wheels towards the direction of rotation. Therefore, the rotation's retraction is done only by the rear wheels.

The advantages of this service are the following:

1) It is valuable because the spinning conditions are very difficult to be reproduced or simulated.

2) It is simple. Only the two devices for measurement of the transversal angle of the directional wheels and the odometer are required.

3) It is safe and quick, because the beginning of spinning is identified immediately, and the directions for the course's correction are supplied immediately.

4) Previous experience of the driver is not required.

5) Special alertness of the driver is not required, but only the quickest compliance to the microcomputer's instructions.

57. Transverse Wind (Detection)

A service for protection of the driver according to which the existence of transverse wind is detected, and the driver is accordingly notified. In none of the examined systems detection of transverse wind is stated. The lack of this service create hazard to the driver, because it usually happens suddenly, during passing from mountainways, bridges, plains etc., or during passing of a truck, bus etc., and it is characterised by intensity which can possibly cause accidents.

The strong transversal wind causes an external torque on the directional system, which is carried on the steering wheel and becomes especially perceptible by the vehicle's driver, who reacts by turning the steering wheel suddenly to the opposite direction. In order for the vehicle to stay in the previous course, the steering wheel must be maintained rotated at an angle φ, during the vehicle's exposure to the transversal wind.

The interruption of the wind is equally dangerous for the control of the vehicle, that forces the driver to turn the steering wheel violently to the opposite direction. The appearance of the transverse wind in waves, as it is known to the drivers, causes a succession of the above described situations and requires very careful driving from the part of the driver, so that hazardous situations may be avoided. Especially when the vehicle speeds, a small deflection from the course often suffices for the vehicle to get off the

road.

According to this service, the data processing system monitors the indication of the steering wheel's sensor and calculates the first derivative $\Delta\varphi/\Delta t$. Hence, measurement of a ($\Delta\varphi/\Delta t>C$), where C constant and stabilisation of the steering wheel at some angle $\varphi_o>\varphi_{max}$, constitute the criteria for the processing system, in order to identify the commencement of the phenomenon and proceed in the estimation of the transverse wind's velocity. From the wind velocity, the processing system calculates a maximum safe speed, compares it with the real speed (calculated from the odometer) and warns the driver to reduce his speed, if needed, at the maximum safe speed levels that it has calculated.

It is clear that the timely notification of the driver at the phenomenon commencement, when the symptoms are not identifiable by him, urges the driver to stretch his attention, and results to avoidance of possible hazardous situations. The processing system notifies the driver by touching, e.g. with the signal "danger", visually or acoustically with a message preregistered in the memory unit (e.g. "Attention Danger, Transverse Wind, Reduce Speed at 50 km/hour").

(2) One Sensor (Steering Wheel Sensor)

<u>54. Road Surface Slip Detection (through the Steering Wheel Sensor)</u>

According to this service, the road slip due to existence of ice, snow, gravel, oil or other liquids, excessive transversal road surface inclination is detected, and the driver is notified acoustically, visually or by touching for impending slip and rotation of the vehicle, so that the loss of vehicle's control can be prevented and the driver be warned to be alert for accident prevention.

The state-of-the-art systems or methods completely lack this service, or at the best case they simply announce messages preregistered in a data base (e.g. "Attention, ice on the bridge during winter"). This means that they do not address an existing danger, but they simply warn the driver always for a possible danger, even when there is none. The routinely repetition of the message is usually ignored by the driver who will probably be not ready when the phenomenon occurs.

In unforeseen events such as water, oil, gravel etc. which do not constitute constant characteristics of the road surface and cannot be stored in the memory beforehand, these systems cannot offer any protection to the driver. The whole operation of the system can be totally misleading, when the driver is being notified e.g. before a turn, that the safe speed limit is 60 km/hr, whereas due to rain, soil and gravel are on the road surface, creating hazards for a vehicle moving at 60 km/hr.

According to the present service the road surface slip due to ice, snow, water, oil, gravel, excessive transversal inclination of the road, is detected. The existence of slippery road is very likely to cause rotation of the vehicle around an axis perpendicular to the road surface and passing through its centre of mass (YAW) and "non compliance" of the vehicle to the steering wheel despite of the driver's reactions. The driver's reactions may be violent turns of the steering wheel, breaking, stepping on the accelerator pedal etc., reactions that do not produce any substantial result, as long as the wheels either rotate without friction (spinning) or lock very easily (with a little breaking) and the vehicle is beyond control despite of the corrective movements of the steering wheel.

The system identifies these symptoms as wheels slip, immediately notifies the driver that a vehicle slip and rotation are in process and guides him/her to reduce the

vehicle's speed without sudden braking so that an almost certain accident is avoided. The slip detection is described below according to one embodiment (from the steering wheel sensor). The second embodiment, that is from the counting of the odometer's pulses, is presented in Chapter e - Para (64). In case of slip of one of the driving wheels (wheel 2) which has a moment of inertia Θ_2, from the acceleration of the wheel (2) it results:

$$F_1 = F_2 + \Theta_2 \; 2\pi n'_2/R, \quad \text{i.e. } F_1>F_2 \quad \text{or} \quad F_1\,L>F_2\,L$$

where F_1, F_2 are the wheel thrusting forces, n_2 the wheels revolutions, R the wheel radius and L the lever on which the thrusting force is applied.

The unequal moments with respect to the centre of mass G provide the vehicle with angular momentum in accordance with the relation:

$$F_1\,L - F_2\,L = \Theta\,(d^2\theta/dt^2)$$

where Θ is the vehicle's moment of inertia with respect to the axis which passes by the vehicle's centre of mass G and θ is the angle of the vehicle's longitudinal axis measured by some fixed vertical plane.

Therefore, the vehicle turns without any movement of the steering wheel. Similarly during deceleration due to slipping wheel, the unequal moments $F_1\,L$, $F_2\,L$ again supply angular momentum to the vehicle. The sudden change of the revolutions of any of the driving wheels, which supplies angular momentum to the vehicle, can be detected by the sudden turning of the steering wheel. Specifically, the slipping of one of the driving wheels (assuming that the other driving wheel is not slipping) causes a sudden jerking of the vehicle to the right or left forcing the driver to turn the steering wheel suddenly to the opposite direction, in order to keep the vehicle in the proper course. When the

slipping wheel is firmly attached on the ground again, the vehicle is once again suddenly jerked to the direction that the steering wheel determines, forcing the driver to turn the steering wheel suddenly to the opposite direction.

The vehicle's data processing system registers the steering wheel's angle φ and continuously calculates $\Delta\varphi/\Delta t$. When the value of $\Delta\varphi/\Delta t$ exceeds a certain value which is considered maximum for normal driving, and in a very small period of time the phenomenon is repeated in the opposite sense, the processing system identifies the symptoms of the phenomenon, issues a warning to the unsuspicious driver and indicates the best handling maneuvers (e.g. "Attention", "slipping in process", "do not use the brakes", "reduce speed slowly" etc.)

The double violation of the maximum value of $\Delta\varphi/\Delta t$ as it was previously described, helps the microcomputer distinguish the slipping from the humps or other obstacles on the road surface (e.g. stones) which also cause sudden jerks at the steering wheel.

59. Directional Wheels Alignment Check

According to this service the adjustment of the vehicle's directional system is being checked, whether it is in accordance to the specifications or not. The directional wheels alignment check is performed by checking the indications of the transversal angle of the directional wheels measuring device only. This constitutes a special feature and innovation of the present method as it was mentioned above, in the sense that the checking is done simply without use of complicated processes or advanced devices.

The embodiment foresees two ways of checking:

(a) *Checking of the indications of the transversal angle*

measuring device for sudden change of the zero point.

When the vehicle travels long distances the average of the steering wheel's rotation angle should be close to zero. This is found by adding (integrating) the device's indications. If the addition, for a period of time, gives a result considerably different than zero, this is an indication of loss of alignment.

(b) Detailed checking of the transversal angle measuring device indications.

In the case of loss of alignment, frequent minor alternations of the indications are observed to one direction, which reflect the driver's continuous effort for the vehicle's restoration on the straight course.

60. Directional System Tightness Check

The lack of tightness in the directional system creates an especially dangerous situation for the vehicle, because it causes knockings on the directional system joints. Beyond a certain limit, those knockings are very likely to cause failure at the directionally system with immediate consequence the vehicle's loss of control.

The method even detects the early stages of the directional system looseness appearance, demonstrating superiority over the other systems, since it controls and protects, as previously mentioned, during the early stages of a hazardous situation. The method is also superior in the sense that the checking is done simply by the indications of the transversal angle of the directional wheels only. According to one embodiment, the looseness existence is detected by the unjustified peaks at the device's indications. Those peaks are caused by the driver's reaction, as follows:

During motion of the vehicle on a straight course, the lack

of tightness prevents the driver from keeping the directional system straight with minor corrections. Due to the looseness, the directional system drags the vehicle towards one direction. In his effort to restore the vehicle in a straight course, the driver transfers the looseness at the other side of the directional system, by turning the steering wheel. The looseness transfer becomes perceptible as an instantaneous knocking and is interpreted as a peak to the indication of the transversal angle of the directional wheels measurement.

(3) One Sensor (Odometer) and Table

CHECKING OF VEHICLE'S AND SURROUNDING ENVIRONMENT'S CONDITIONS WITH REFERENCE TO STANDARD CONDITIONS

A series of services that concern the checking of the vehicle's condition and the surrounding environment's conditions and the protection in case of hazardous situations, which rely on the analytical processing of the indications of the odometer's for the travelled distance and vehicle's speed and comparison with standard indications which are identified and registered in the system's memory in special environmental conditions (ascending road, adverse weather conditions, bad vehicle's condition).

The state-of-the-art systems use:

a) Sensors installed in different vehicle locations for checking of various systems condition.
b) Sensors installed at various locations of the road network or signals from central offices or satellites for checking of environmental conditions, resulting in significant increase of the complicity, volume, cost and data processing time for extraction of conclusions. Another disadvantage of the state-of-the-art systems is the high technology which they employ for the devices and sensors, in order to overcome the conditions prevailing during driving

(continuous vibrations, temperature increase, adverse environmental conditions).

Specifically, due to the high cost of those systems, only few are in use in production vehicles. For the state-of-the-art systems, the following two are mentioned:

a) For the tire pressure check.
b) For the breaks wear check.

So,
a) For the tire pressure check, pressure measurement sensors are employed (Manometers), one on each tire, and their decoded signals are presented to the driver, issuing a warning in case of dangerous loss of air. The system has been applied on the experimental vehicle PEUGEOT OXIA.
b) For the brakes wear check two electrodes are employed, which are implanted in a certain depth into the brakes pads. When the brakes wear is well advanced, reaching the implanting depth of the electrodes, then they simultaneously, make contact with the friction disc. These two electrodes are part of a circuit that includes power source and indicative light. The light is normally off. When the two electrodes touch the friction disc the circuit closes and the light turns on, notifying the driver for brake wear.

A characteristic disadvantage of this system, is the fact that it doesn't notify for a behavior change of the braking system caused by other reasons e.g. overheating, dampness etc. At the present series of services, only one sensor type is used for the measurement of the distance travelled by the vehicle at any time. The sensor's indication divided by the elapsed time shows the vehicle's speed. The vehicle's speed indication, presents fluctuations during driving mostly due to the fact that the driver cannot by nature, keep completely stable or completely smoothly changed (constant acceleration) the vehicle's speed, but it continuously

increases and decreases the speed mostly due to the changing pressure that the driver applies on the accelerator pedal.

The minor alternations of the speed, especially at the pressure's alternations points [Figure (89)], where the speed presents a local peak is enlarged and compared to standard minor alternations that concern special conditions and are registered into the memory. The registered indications of special conditions concern e.g. indications in cases of front wind, overweight, worn-out brakes etc. Comparing the measured indications to the registered ones, the special condition of the said vehicle results.

Besides the simplicity and low cost of the present method, another advantage causes from the fact that it does not measure or determine directly the vehicle's particular problem or the environmental conditions, but indirectly their influence on the vehicle's behavior on the road. Practically, this is mostly what is wished for, that is the driver's protection in case of change in the vehicle's behavior and not so much the determination of special conditions or problems. So, for example, the degree of the brakes wear barely interests if it does not influence the vehicle's behavior and the braking process. On the contrary, if the breaks overheat, a significant change is observed at the vehicle's behavior, even with minimum brakes wear.

For the embodiment as vehicle's travelled distance measuring device, a high-resolution rotary encoder is preferred for more reliable recording of the speed details. This encoder inputs in the data processing unit a certain number of pulses per unit of travelled distance. Division of the pulse number by the recording time presents the vehicle's speed in time increments as small as the selected interval. A speed registration from two pulses only and division with the period of time between these two pulses is preferred.

A diagram is so formed by the odometer's indication, where

the speed's minor alternations are registered in detail for infinitesimal periods of time (e.g. for rotary encoder of 1026 pulses per rotation, the speed's registration is possible every 2mm of the course). From this diagram the average vehicle's speed is determined per larger course length e.g. per 30m of travelled distance, and the speed's minor changes are examined at the points where the detailed speed diagram presents local peaks.

The local maximums of the registered speed correspond to the points where the vehicle at first accelerates and then decelerates (e.g. by application of pressure and release of the accelerator pedal) and the local minimums of the registered speed concern the next action, that is release and then application of pressure as in Figure (90). These minor alternations occur at constant infinitesimal periods of time, and are mostly depended on the driver's reflexes in his/her effort to keep the vehicle's speed constant. Hence, for the same speed the minor alternations present a high degree of periodicity. These minor alternations present some characteristics which are indicative of the vehicle's or the environment's conditions.

For ideal environmental conditions and perfect condition of the vehicle, the minor alternations have the form of figure (91). They present a symmetry and end in a sharp edge at the local maximum or minimum. As the vehicle's speed increases, at the speed versus travelled distance diagram, the alternations slope before or after the peak diminish. This happens because at high speeds the minor changes of pressure applied on the accelerator influence less the speed's change. This is numerically proven by the energy that is needed for change of speed at low or high speeds. e.g. a 1000 kg vehicle in order to accelerate from 0 to 30 km/h requires energy:

$$E_1 = \frac{1}{2} m(U^2 - U_o^2) = \frac{1}{2} 1000 \left[\left(\frac{30\text{x}1000}{3600}\right)^2 - 0^2 \right] = \ldots$$

For acceleration from 100 to 130 km/h:

$$E_1 = \frac{1}{2} m(U_2{}^2 - U_o{}^2) = \frac{1}{2} 1000(130^2 - 100^2)\left(\frac{1000}{3600}\right)^2 = \ldots$$

We notice that $E_2 >> E_1$

therefore for the same E1 = E2, i.e. the same pressure alternation on the accelerator at high speeds, influences less the kinetic energy change.

61. Vehicle's Mass Estimation (Overweight)

In the case of overweight load, during the speed's minor alternations due to the driver's minor corrections, the vehicle behaves as follows:

Upon application of pressure at the accelerator pedal, the vehicle accelerates very slowly due to the vehicle's higher inertia. When the accelerator is released, the vehicle delays restoration to the initial speed due to higher inertia. In figure (92), during deceleration, the slope is less than the normal. Transition from acceleration to deceleration is smooth as shown by the blunt shape of the peak in figure (92).

For higher speeds, as in the case of ideal conditions, a reduction of the curve's slope is exhibited, which is caused by inertia, as it was discussed above. The diagrams for overweight vehicles at different speeds are shown in figure (92), where indicative acceleration values before and after the peak are shown. The slopes vary in proportion to the overweight load.

Road Slope - Contour Mapping

In case the vehicle moves in areas of acclivity or

declivity, during speed's minor alternations, for uniform application of pressure or release on the accelerator the following are observed.

a) <u>Acclivity:</u> In the case of acclivity, during application of pressure accelerates slowly, therefore the initial part of the alternation has a small slope. On the contrary, during release, the vehicle decelerates quickly and so the second part of the alternation has a large slope. Furthermore, the diagram presents a sharp at the peak, due to immediate response of the vehicle to the alternations.

Figure (93) shows the alternations at the peaks in the case of acclivity. In the case of high speeds, as the speed increases, the rate of increase or reduction of speed is decreased. The slopes vary in proportion to level of acclivity.

b) <u>Declivity:</u> In the case of declivity, the minor alternations concern case of a vehicle's movement with use of the motor as decelerator, with the same speed as for the ascent. The driver uses the accelerator for minor corrections and the brakes for the case of large slopes. In both cases the minor alternations are detected.

A characteristic of the minor alternations is the abrupt acceleration of the vehicle or the almost negligible deceleration. Substantially, the driver must successively decelerate the vehicle in order to avoid excessive accelerations. The alternation from acceleration to deceleration is done smoothly as shown in figure (94). The slopes vary in proportion to the level of declivity.

<u>63. Front and Rear Wind (Detection)</u>

In case the vehicle moves under the influence of a front or rear wind during the speed's minor alternations, for a uniform application of pressure or release on the

accelerator pedal, the following are observed.

a) Front Wind. In the case of front wind, during application of pressure the vehicle accelerates at a lower rate than the ideal condition but usually higher of the case of acclivity. During the accelerator's release, the vehicle decelerates at a higher rate than the ideal case, but lower than the case of acclivity. Generally, it can be proved that the drag forces due to the blowing of wind, influence the vehicle's resistance much less than the corresponding forces due to acclivity or declivity.

Another feature of the alternations, is the abrupt transition from acceleration to deceleration, meaning that a sharp edge exists at the peak. The slopes vary in proportion to the wind speed [Figure (95)].

b) Rear Wind. In this case the vehicle's speed minor alternations have the following characteristics. There is smooth transition from acceleration to deceleration (no abrupt change is observed). The speed's increase rate is high and the reduction rate is low. Anyhow, these rates are lower than the case of declivity. Again, for high speeds the increase and decrease rates are lower. Figure (96) shows the alternations for the case of rear wind. The slopes vary in proportion to the wind's speed.

The above mentioned, concerning checking of OVERWEIGHT LOAD - ACCLIVITY - DECLIVITY - FRONT WIND and REAR WIND are registered in the memory unit in the form of a table which is schematically presented in figure (97).

Depending on the odometer's indications, the most appropriate case that fits best to the measured alternations of accelerations and decelerations, is selected from the table. For cases that they are not registered precisely, interpolation from the table is performed.

64. Balancing (Detection)

In case one of the vehicle's wheels is not balanced, vibrations appear at the directional system, which usually become perceptible by the driver as steering wheel oscillations. These vibrations are periodic and demonstrate amplification at a certain speed where there is resonance with the natural frequency of the vehicle's frame. Practically, as the vehicle's speed increases, the amplitude of the oscillations continually increases, to a limit where an abrupt increase appears. The balancing check is done by examination of the indications of the transversal angle of the directional wheels sensor, with respect to the appearance of periodic oscillations which are growing as the speed increases. Figure (98) shows such an indication graph for the case of non-balanced tire.

65. Road Slip - Ice (through Odometer)

According to this service the beginning of ice formation on the road surface is being checked, and the driver is being notified in proportion to the danger level. Furthermore, the initial ice formation way on the road surface is taken under consideration. During the early stages of formation, the ice creates small icy spots on the road surface, which are enlarged until the whole road surface is covered by ice.

At these spots each traction wheel slips locally. This slip is detected by the abrupt increase of the connected to the wheel odometer's indications. Hence, at the indication of the vehicle's speed, abrupt exaltations appear, and their width and duration depend on the ice formation stage on the road surface. Therefore, detection is possible not only for the ice existence, but also for its danger level, thus resulting in the driver's proper warning and protection. Figure (99) shows the odometer's characteristic indications which reveal the formation of ice.

66. Aqua Planing

According to this service, the water layer formation on the road surface is checked from the beginning, and the driver is timely warned for danger against slip. Furthermore, the odometer's indications are checked for existence of exaltations. These exaltations are not so abrupt as in the case of ice but they are characterised by the abrupt drop, due to the wheel's abrupt contact with solid ground. Figure (100) schematically shows the odometer's indications diagram, where the aqua planing phenomenon appears.

67. Proper Speed when approaching Traffic Lights and STOP Signs

The majority of the traffic signs appears before crossroads or transportation nodes. The method informs the driver ACOUSTICALLY, VISUALLY or BY TOUCHING:

1) about the oncoming traffic signs, such as STOP - ATTENTION - TRAFFIC LIGHTS - PEDESTRIANS CROSSING - HOSPITAL - SLOW - SPEED LIMIT
2) about the driver actions (e.g. speed decrease, turning prohibition etc.)

In case the traffic signs dictate speed reduction and vehicle's complete stop (STOP sign, crossroad with priority road, traffic lights etc.) the driver is notified at sufficient distance before the said sign, so that he/she has the chance of timely vehicle immobilisation. The approaching speed is calculated based on the registered data of the road surface in the memory unit and the data from the table of Figure (97). For the determination of the total minimum length required for the vehicle's immobilisation, the following formula of Appendix (I) is used:

$$S = \frac{m}{2F_2} \ln \left[1 + \frac{F_2 U}{F_1} \right]$$

An example of calculation of the minimum length required for immobilisation of the vehicle, for certain parameter values which are stated in Appendix (I), is table (11), which is edited for:

Vehicle mass	m = 1000 kg
Wind speed	w = 0 m/sec
Road slope	u = 0°
Braking force	T = 2000 daN
Friction factor	μ = 0.6 [Table (10)]

From the above data, a total vehicle's deceleration γ results in the order of 0.1g to 3g for different braking force at every initial speed. Obviously, by changing the problem's parameters, e.g. the wind speed, road slope, friction factor, different intervals for immobilisation are resulting. Finally, the suggested immobilisation length results for the most unfavorable case of parameters.

From all the examined systems which are presented at the beginning, none foresees such warning interval for oncoming traffic sign, so that the driver may change the vehicle speed (e.g. immobilise). It is well known that the non-timely compliance to the traffic signs constitutes a major cause of accidents.

Normally, the oncoming crossroad's type is pronounced first, and then the proper vehicle speed. In case of speed reduction, due to the fact that the driver cannot estimate correctly the speed, so,[;e notification about speed reduction is not sufficient, but it is necessary that the driver is notified continuously. This is embodied as follows:

The notification is heard and appeared on the display, while at the same time a message is continuously pronounced "SPEED REDUCTION, SPEED REDUCTION" until the speed reaches a tolerable limit. The driver cannot always estimate properly

ROAD TYPE	ROAD CONDITIONS	TYRE QUALITY NEW (μ)	- USED (μ)
Grained asphalt	Dry	0.9	0.9
	Wet	0.7	0.5
Common asphalt	Dry	0.8	0.8
	Wet	0.65	0.56
Smooth asphalt	Dry	0.6	0.6
	Wet	0.65	0.3
Smooth cement	Dry	1.00	1.00
	Wet	0.7	0.5
Asphalt	Mudded	0.15	0.10
	Iced	< 0.10	< 0.10

(μ) = Friction factor between tyres and road for different conditions of road and tyres.

TABLE (10)

VEHICLE	Smin for	% CHANGE OF Smin for																	
SPEED	w=u=0(μ=0.6	w= +2	w=+10	w=+2=	w= -5	w=-10	u=+15	u=+10	u= -5	u=-10	μ=0.6	μ=1.0	λ=0.1	λ=0.3	m= Kg	m= Kg	C_D =	C_D =	PROPOSED
Km/h	m=1000Kg)	m/sec	m/sec	m/sec	m/sec	m/sec	m/sec	m/sec	m/sec	m/sec					1000	1500	0.3	0.3	S
20																			
40																			
60																			
80																			
100																			
120																			
140																			
160																			
180																			

TABLE (11) - Minimum distance for vehicle immobilisation for various parameters values [Appendix (I)]

for braking, and he often experiences difficulty. By this Method of Warning at turns or STOP signs, more safe driving is insured. What the driver was doing until now by experience or by the books, that is how many meters before and at which speed he/she should brake, a problem that the driver could not solve until today, is now 100% solved. Besides that, for the same driver and the same vehicle there are many parameters, such as: Passengers number, weather (rain, snow etc.), road surface type.

68. Proper Speed before and during a turn

According to this service, the maximum allowed vehicle's speed before a turn is calculated, so that the vehicle will not show understeering or oversteering, or be shaken off the road. Furthermore, the reaction forces that are acting on the wheels are continuously monitored during the entrance in a turn, the turn's execution and the exit from it. The driver is notified visually, acoustically and by touching to adjust his/her speed properly to the maximum allowed one (if he exceeds it), at a distance which is sufficient for braking, and he is guided during the turn in relation to the corrective manoeuvres which are required, in order to keep the vehicle under control.

The road surface data are registered in the memory unit (Chapter b) while the conditions that prevail and the vehicle's condition are found from the table of figure (97). The previously examined systems, regarding the safe turn execution, are limited at the announcement of the oncoming turn only, and the road surface condition or geography, i.e. they employ data, concerning the topography, traffic signs or information about the road network, which are preregistered in some memory unit.

The disadvantages of the state-of-the-art are:

1) The assistance services do not warn for an existing

danger based on real facts, but they only alert the driver for the existence of turn, slope and road surface condition. Hence, warning for e.g. ABRUPT TURN or TURN WITHOUT PROPER ROAD SURFACE INCLINATION does not necessarily mean a hazard when the vehicle's speed is not high.

2) In the common systems the assistance services provided, do not rely on real danger facts, therefore the drivers usually distrust the messages, and do not strain their attention, considering that the warning is in excess. Therefore, when they are warned about ABRUPT TURN AND SLIPPERY ROAD SURFACE, during the summer, it is easy for them to underestimate the warning and show the same indifference during winter, with disastrous consequences.

3) The driver's informing is STATIC, meaning that it depends on the registered in a data base data, and not DYNAMIC, meaning that it is not capable of warning the driver for either excessive speed before the turn entrance or for slippery road surface which is caused by unpredicted events (e.g. oil).

According to the present service, all the road surface data and the vehicle's data (mass, speed, width, slope, road surface quality, duration, turn's curvature radius etc.) are registered and the maximum speed Umax for safe approach to every encountered turn, and the minimum distance Smin from each encountered turn, where the vehicle must start braking are calculated, in order for the driver to reduce speed at safe levels, before he reaches the turn. The weather condition data and the vehicle's condition are shown on figure's (97) table. In case the speed or distance exceed the calculated safe values, the driver is notified visually, acoustically or by touching to proceed in corrective actions (e.g. minimise speed, do not turn etc.) in order to avoid the accident.

Furthermore, the ground reaction forces acting on the wheels during the turn are calculated, and the driver is notified with the above mentioned three ways to proceed with

corrective actions that will facilitate the better wheels' traction on the ground, e.g. push smoothly the brakes (at the turn's entrance), accelerate (at the turn's exit) etc. It is understood that the friction factor with the ground is not considered constant, but depends on the tires' wear, the weather and unpredicted events, such as oils spilled on the road surface etc. The maximum friction factor μ max is a quantity continuously monitored, as referred in Chapter e - Para (65) about Slippery Road (ice etc.).

The main advantages of the present method are:

1) The protection is continuous and DYNAMIC, with the system calculating various quantities and warning the driver only when there is real danger, instead of repeating monotonously different messages stored in some data base.

2) The range of protection is very large and is not exhausted at the announcement of a maximum safe speed, but the Umax is calculated taking into consideration the weather, tires wear, unexpected road surface slip etc., and then the driver is notified about the minimum distance available for his/her vehicle's braking. The tire's traction on the ground is also registered at every time, and the driver is notified to react in a hazardous situation (understeering, oversteering), just like an experienced racing driver.

3) It provides additional protection to the driver, even if the warnings are ignored by the driver when this is possible (e.g. when the vehicle speed exceeds Umax, he/she is warned "do not turn at the oncoming crossroad).

4) It does not disturb the driver with useless messages when a danger doesn't appear during the execution of the turn.

5) It teaches, in a way, the driver in relation to the best way of the turn execution and transmits knowledge to him/her that until now only few drivers knew (e.g. racing drivers, very experienced drivers).

In figure (130) the maximum speed's Umax approximate calculation is indicated for the safe turn execution. In Appendix II, the vehicle's dynamic behavior is studied before, during and after the execution of a turn. The wheel's traction is the major criterion for calculation of the maximum speed on a particular turn. The system notifies the driver when he/she is going to exceed this limit <u>during the turn's execution</u> (e.g. "reduce speed") and notifies him by a characteristic way when he exceeds the limit (e.g. "attention understeering anticipated, get ready to turn the steering wheel right").

<u>69. Suspension System</u>

The suspension system check is performed by comparison of the odometer's indications details during the vehicle's start or during the vehicle's immobilisation. In case of bad suspension, the vehicle starts with hysteresis with reference to the foreseen acceleration under ideal conditions due to the fact that part of the supplied energy is spent during the vehicle's oscillation. Furthermore, during braking or immobilisation, the vehicle oscillates resulting to a friction force which is not constant. This means that during the start and during braking, oscillations are detected at the odometer's indications, with reference to the ideal conditions, resulting in loss of kinetic energy and larger braking distance [Figure (102)]. According to this service the suspension's bad condition is checked even in conjunction with other problems, such as during warning at turns, stops, etc.

<u>70. Brakes - Extent of Wear (Through Table for Braking Distance)</u>

According to Table (11) - the vehicle's immobilisation distance for various parameter values, results for each parameter that is found by the Figure's (97) table (Memory unit table for detailed check of indications.) If the real

braking distance is found larger than the one foreseen by the table, it is clear indication of brakes wear, which is detected as to its extend by the extend of the variation.

71. Tyres - Extent of Wear (Measured by the Distance of Braking)

As in the case of the brakes' wear check, the Table (11) (Vehicle's Immobilisation Distance) for various parameter values that are found from Figure's (97) Table (Memory Unit's Table), which provides the immobilisation distance. In the case of worn-out tyres, the tyres' friction factor with the ground is lower, resulting to increased braking distance.

But this distance is not registered at the odometer's indication (as in the case of worn brakes) but the odometer's indication (since it counts the tire's rotation) is normal. The braking distance's deviation is determined by another position estimation method. For this case, the deviation is indication of the tyres' wear.

72. Lubricant and Refrigerant

The method warns the driver for the following:

a) reduction of the lubricant's or refrigerant's level
b) unsuitability of lubricant and refrigerant or their change of properties.

At these cases the odometer's indication is checked and compared with standard indications. The following are observed:

In the two previous cases, an increase in the engine's temperature is initially observed which results in the decrease of the lubricant's viscosity. The power that the engine produces, initially increases and the acceleration

rates increase compared to the ideal ones. But afterwards, the engine's temperature increase results in loss of the lubricant's properties and the friction continuous increase, resulting in a continuous drop of the rendered power. The acceleration rates decrease until the total loss of the lubricant properties and the engine's destruction.

According to this service the driver is warned at the first symptoms of the two previously mentioned cases for avoidance of motor's further damage.

73. Motor Power (Electrical System)

The electrical system's check is performed by the odometer's indication and is characterised by instantaneous interruptions of its normal operation. These interruptions are caused by non activation of some spark plugs in the corresponding cylinders. Figure (103) shows schematically the vehicle's instantaneous decelerations due to the vehicle's electrical system bad condition.

(4) One Sensor (Odometer)

74. Vehicle's Overweight Control by the Tyres' Distortion

The check in this case is performed through measurement, by the odometer, of the travelled distance by the vehicle between two successive turns and its comparison to the distance which is registered into the memory. From the beginning, a deviation appears, which remains constant for every such comparison. The constant deviation constitutes a tyres radius distortion indication due to overweight load, since for the case of tyre's wear, deviation is slow and progressive, and for the tyre's pressure loss it is continuously increasing. The driver is notified accordingly, visually, acoustically or by the touching device.

75. Tyres' extent of Wear (Diameter reduction)

A protection service where the tyre's extent of wear is determined by the tyre's diameter reduction and the driver is notified accordingly. The vehicle navigation relies on the proper distance measurement. The measurement is performed by sensors installed at the wheels or on few of them [Chapter a - Para (1)]. Every section of the course that is enclosed by two turns, is continuously compared to the length that has been registered in the data base. Hence, as it was already mentioned, an odometer's correction factor K results, which is used for the correction of the odometer's errors that due to flat or worn tyres, overweight vehicle and tyres loosing air.

The tyres' wear entail a small reduction of the diameter which contributes to odometer's continuous error. So, if at a specific distance S a new properly inflated tyre, of diameter D, performs n rotations, a worn, properly inflated tyre of diameter D-ε, performs n' rotations. From the relations $S = \pi.D.n$, and $S = \pi.(D-\varepsilon)n'$ the wear results as

$$\varepsilon = D(1-n/n')$$

Therefore, it is possible, the tyre wear depth to be automatically calculated for every distance S, and when it exceeds some limit, the driver be notified for the tyres' wear, in order to start scheduling their replacement. When the wear advances, then he/she is notified for a second time and when the tyre, based on the calculations, is completely worn out, the driver gets the third and final warning.

A wrong calculation due to deflated or overweighted tyres is excluded, because the tyres' wear is a very slow process and the processing system detects abrupt or continuous changes of the diameter, and will identify another cause such as the ones that have already been mentioned.

76. Tyres' Pressure Check

The check is performed by measuring the travelled distance between two consequent turns, as is measured by the vehicle's odometers, and comparing it to the registered into the memory unit travelled distance. When tyre's pressure loss exists, a difference appears which increases progressively but more intensely than the case e.g. of normal tires' wear. The service estimates the starting of pressure loss and the loss rate, and the driver is notified accordingly. The pressure loss rate is also used as indication of the course which the driver can follow (e.g. to the closest gas station) before total pressure loss. According to another embodiment, odometers are foreseen on all the vehicle's tyres, and the indication of each one of them is checked against the others for detection of pressure loss.

(5) Protection - General

77. Transmitters - Protection

By the present method, detection of ice, strong winds, aqua planing, at the early stages of their appearance, is possible, by use of odometer and wheel's transversal angle sensor only, as it was mentioned in Chapter e (3). In a different embodiment, adverse weather conditions hazardous to drivers, are detected by use of transmitters which are placed in areas where a possibility of adverse weather exists. More analytically:

(a) Transmitters are placed at roads sections where strong winds frequently occur, presenting a hazard for drivers. These transmitters are activated by an anemometer when the wind speed exceeds a safe limit and they transmit a signal, which the system's receiver decodes to the message "Strong Wind".

(b) Transmitters are placed at roads sections where water

is usually concentrated in larger amounts than usually consisting a hazard to safe driving. These transmitters are activated by a sensor measuring the water level, when it exceeds the safety limit, and they transmit a signal that the receiver-computer receives and decodes to the message "Attention! Water".

(c) Transmitters are placed at sections where ice formation is more likely to appear. A mechanism activates the transmitter only when the ice starts forming on its sensor. So the code message "Attention! Ice", which is received by the approaching vehicles' receivers in order to reduce speed, is transmitted. When the ice melts, the "Attention Ice" code message's transmission is automatically cancelled.

(d) Transmitters are placed at sections where fog is likely to appear. A mechanism, similar to a photocall, measures the fog density, by the passing light beam, and when it exceeds the safety limit, then the transmitter activates, transmitting the code message "Attention! Fog" which is received by the approaching vehicles' receivers. Therefore, the drivers are informed about the fog's density, and decrease their vehicle's speed. When the fog dissolves, the beam of light passes through freely and the transmission of the message "Attention! Fog" is automatically cancelled.

The above mentioned methods assist significantly to the avoidance of frequent accidents and multiple collisions. Usually the warnings of the traffic signs for possible existence of ice or fog are not taken seriously by the drivers since the possibility is low and the signs are permanently there either during good or bad weather. But the acoustic warning for ice existence alerts each driver even if the warning is issued at the early stages of the ice formation.

78. Warning for Reverse Movement

It is often observed that vehicles roll backwards during

waiting times. Even worse, frequently drivers use, by mistake, reverse or even forget that the vehicle is at reverse gear. For these cases, an installed sensor registers the wheels' reverse movement. Therefore, when the microcomputer realises that the sensor counts pulses, it notifies the driver acoustically ("Reverse"), visually or by touching, with repetition of the message every 3 sec. Naturally, this reminder does not disturb the driver, but on the contrary, it alerts him since there is always a danger when he reverses. According to another embodiment, the travelled distance measurement devices [Chapter a - Para (4)], are capable of detecting the vehicle's reverse movement.

79. Electronic Horn

According to this service a special signal is transmitted by the vehicle's transmitter [Chapter d - Para (32)] which is received by the nearby passing vehicles, is translated to acoustical, visual or by touching warning to alert the driver. The signal is transmitted directly by the vehicle's processing system or by the driver himself, by pressing a key corresponding to the sound device (horn). The signal is transmitted in case the processing system, upon comparison of the road network data to the vehicle's course and the driver's maneuvers, determines hazard for the nearby drivers and for the vehicle itself. Furthermore, the driver preventively activates the signal transmission in order to alert the other drivers. The signal, upon reception by a nearby vehicle is translated to either a simple acoustic, visual or by touching warning (sound, light etc.), or to a specific acoustic, visual or by the touch device message, e.g. traffic light violation, speed limit violation.

The nearest to the proposed device is the well known "horn" of the vehicles, that is the sound device which is activated by the driver for the other drivers' warning. Special cases of such use constitute the police cars, fire fighting

vehicles or ambulances etc., which continuously transmit a visual or acoustic signal (siren, blinking lights of several colors), warning the drivers for their passage and requesting granting of priority and driver alert.

The well known "horn" of the vehicles is activated by the driver, usually when another vehicle driver is about to perform a maneuver that is considered hazardous to the first vehicle, more rarely in order to alert other drivers that the user is about to perform a maneuver. Additionally, the acoustic warning intends to alert pedestrians which are on the vehicle's course.

The main disadvantages of the state-of-the-art are:

(a) Environment noise pollution
(b) Confusion as to the signal's receiver (all the drivers receive the same signal)
(c) Confusion as to the alert's object
(d) Total confusion as to the alert's object, when most of the drivers use the "horn"
(e) It requires identification of the hazard by the driver
(f) It scares the driver when he is not prepared for it
(g) It does not warn the other drivers for the vehicle's hazardous manoeuvres or offenses which are performed without the driver's realisation
(h) The use is left on the driver's judgement and not on objective requirements
(i) It is not used when the driver proceeds to an offense or to improper manoeuvre for other drivers' warning, or when the driver is drunk or sleepy etc.
(j) It is not used when the vehicle is parked or abandoned at a dangerous for other drivers spot

The data processing system activates the vehicle's transmitter for transmission of an alerting signal, when, by comparison of the road network data as they are registered in the data base to the vehicle's movement and the driver's manoeuvres, it detects that the vehicle's movement is beyond

the limits of safe driving. The limits of safe driving result from:

* vehicle's speed and geometry criteria in accordance or not to the road network topography's requirements
* the vehicle's general course in accordance or not to the traffic sign data
* vehicle's manoeuvers which result from the driver's actions, in accordance or not to the requirements of safe driving

Activation of the transmitter by the data processing system also occurs in case of detection of not smooth vehicle movement (abrupt stop, sharp turn etc.). The transmitter is also activated by the driver when a particular reason for warning exists.

The advantages from the present service application are the following:

(a) There is no noise pollution because the signal consists of transmission in the range of E/M radiation.
(b) The drivers attention is alerted for hazard resulting from the course of the vehicle which transmits the signal. This way, the vehicle and the driver that first transmits the signal are mainly protected, and the other drivers receiving it, as well.
(c) The warning is clear and concerns a certain reason for alerting the driver (excessive speed, traffic light's violation etc.). It is not characterised by the usual horn's obscurity which is used upon suspicion of an oncoming hazard or a possible maneuver performed by the driver.
(d) It does not require driver's participation at the use of the transmitter. The detection of a possible danger is performed by the processing system.
(e) The processing system transmits the signal even when the driver is not in good condition or is not aware of his condition (sleep, drunk etc.).

(f) The processing system is capable of activating the transmitter even in case of vehicle's stop or parking (creating hazard to other drivers).

Other advantages will be mentioned after presentation of the embodiment. The registration of the road network data was described in detail in Chapter b. For the vehicle's course and the data concerning position, speed, wheel angle etc., the embodiment refers to Chapter d, for the vehicle's position and the directional wheels angle of turn. The processing system operation and its connection to the transmitter and receiver is shown in Chapter a - Para (1).

A first embodiment of the present service is shown in Figure (104). In this figure the data processing system is shown connected to the odometer and the measuring device for the transversal angle of turn of the directional wheels, the data base and the alerting signal transmitter. The other devices that constitute part of the invention are not presented in this Figure. Also shown in the Figure is the transmitter's activation key, which activates the transmitter without intervention of the processing system, depending on the driver's judgement only.

The determination and confirmation of the vehicle's position on the road network were described in detail in Chapter d - Para (35) - (38). The vehicle's movement checking, with respect to the traffic signs, the topographic data, the areas and the buildings from both sides of the road network are described in Chapter d. The data processing system activates the alerting signal transmitter in the following cases:

1) When the vehicle's movement data make the driver's compliance to the traffic signs, impossible or ineffective. Examples of these cases are:

* When the vehicle's speed is such that complete stop at a

STOP sign or compliance to a right of the way sign, is impossible.

* when the vehicle's speed is such that complete stop at pedestrians' crossing is impossible.

2) When the vehicle's movement is not conforming to the safe driving rules, that is

* when the driver is under influence of alcohol, exhausted, or simply absent minded [Chapter e - Para (54)],
* when hazardous maneuvers are performed, which are possible to lead to vehicle's loss of control,
* when the vehicle passes to the opposite traffic lane on two-way streets [Chapter e - Para (53)],
* when it brakes abruptly,
* simply as a warning, upon approaching a crossroad with no priority signs,
* when driving at night or in a tunnel with the lights off.

The vehicle's time is determined by a microcomputer's chronometer, while the lights status is determined with a simple zero-one connection to the microcomputer.

3) The vehicle's movement or stop is in violation of traffic signs, that is

* when the vehicle moves with speed higher than the maximum speed limit and lower that the minimum speed limit,
* when it stops at an area where stopping or parking are prohibited.
* when it turns where it is prohibited or when the directional lights indicate intention to turn at a direction that is prohibited,
* when passes outside a school, a camp etc. for warning,

4) When the vehicle's motion data, compared to the road network's topographic data, endanger the vehicle's or the driver's safety, that is

* when it approaches a turn with speed higher than the safety limit,

* when it approaches areas of slippery road surface, at high speed, etc.

5) In case of collision. The vehicle's collision is detected with one of the following ways:

* Vehicle's abrupt stop. The odometer suddenly interrupts transmission of pulses [Chapter G - Para (92)].

* Disturbance from the transversal angle of directional wheels measurement device.

* Use of accelerometer and its connection to the processing system for check of vehicle's acceleration rate.

According to a second embodiment, the vehicle's microcomputer connection is foreseen to the usual vehicle's horn, so that - together with the attention signal transmitter's activation - an acoustic signal be given.

According to a third embodiment the transmitter is activated and transmits various code messages, depending on the cause that activated them. These code messages are translated via the data base of the receiving vehicles to corresponding warnings. According to this embodiment the vehicle's characteristics are transmitted for more complete warning. Examples of such transmission signals are the following:

- Red ALFA ROMEO exceeds the speed limit,
- Red ALFA ROMEO is driven recklessly,
- Red ALFA ROMEO driver is drunk, sleepy, etc.
- Red ALFA ROMEO requests priority, etc.

80. Guidance in Tunnels

According to this service, detailed information is provided to the driver during passage from tunnels. Registration at

the memory unit is embodied using two imaginary nodes at the entrance and exit locations of the tunnel. These nodes have a special code e.g. TUN-44 in order to indicate that the interval between them is underground. The supplied instructions concern:

(a) Proper use of the vehicle's head lights (e.g. turn on - turn off lights). According to one embodiment, sensors are foreseen at the vehicle's electric system for checking of proper use of the projectors during passage from tunnels.
(b) Speed limits, maximum and minimum, wherever it is foreseen.
(c) Estimated passage duration.
(d) Other instructions regarding particular features of each tunnel.

81. Warning for Improper Manoeuvre (Blinkers)

According to this service, detectors are installed in the vehicle's electrical circuit that controls the direction indicator lights (blinkers). Upon activation of the blinkers for turning (right or left), the vehicle's processing system checks if the turn is allowed or prohibited (one-way streets). In case it is prohibited, it notifies the driver visually, acoustically or by the touching device.

82. Warning for Avoiding Traffic Violations

According to this service, the driver is notified during his passage from road network's areas about prohibitions or limitations that are valid at the particular areas. These data are registered in the memory unit. Such warnings, according to one first embodiment, are:

* Speed limit (maximum or minimum)
* Parking prohibition
* Stop prohibition

* One way
* Passage of trolley-car, train etc.

According to another embodiment, the driver is notified about the consequences that some traffic violation at that point may have, e.g. tickets for illegal parking etc. This feature is especially useful during driving in foreign countries where the foreign driver usually ignores the local Traffic Regulations and the foreseen penalties, frequently resulting in inconvenience.

83. Road Network Points with Increased Frequency of Accidents

According to this service, the road network points or areas where increased number of accidents is statistically observed are registered - classified according to the accidents causes - in the data base, where during the accidents at these points or areas of the road network registration, the degree of hazard and the cause of it are announced visually, acoustically or by touching to the driver and depending on the cause, the appropriate information for maneuvers for passage from this area are provided (e.g. decree of low speed limits, driving at the right side of the road etc.).

In all the examined systems or methods, the drivers protection and checking services are exclusively provided based on the road network's condition and modulation and not on the condition of the traffic at each part of the road network, as it is modulated during the time of the vehicle's passage. That means, the checking and protection services use data which concern the topography, traffic signs and information for the road network, same to the ones that concern the routing and guidance services, and from them conclude the degree of hazard of each part of the course. If the system or the assistance method use an external infrastructure (e.g. transmitters, satellites, central

stations etc.), again the data taken under consideration by the vehicle's processing system for determination of the degree of hazard, concern the road surface's or the road network's condition at that moment or the next ones.

Examples of such services from the examined systems are:

* depending on the traffic signs, driver's warning for oncoming danger, e.g. "Attention slippery road", "Attention strong winds", "Approach to an unattended railroad crossing".
* depending on the road surface's topographic modulation, drivers warning for oncoming danger, e.g. "Dangerous declivity", "Speed limit for turns", "Continuous turns",
* depending on the traffic,
* depending on the buildings existing at both sides of the road network, e.g. "Factory exit", "School - Slow", "Entrance to an urban area".

With reference to the provided service, the disadvantages of the examined systems are the following:

1) The assistance services do not warn for danger based on real data, but they just consider the possibility of danger. Therefore, warning for e.g. "Slippery road" or "Continuous turns", do not necessarily mean existence of danger.

2) Substantially, the provided services recommend the driver's attention and decree minimum speed limits (or immobilisation), and rarely propose or recommend different kind of actions, such as "Vehicle passing is prohibited". However, there are cases not covered by driver's similar actions or any kind of traffic signs. Such cases are e.g. the enforcement of use of fog lights (yellow color), the enforcement of use of chains etc.

3) Since in the usual systems, the provided assistance

services are not based on existing danger, the drivers are usually distrustful, they are not very alert, or they do not usually reduce the vehicle's speed, in case of safe passing by some hazardous point or if the drivers determine by frequent passing, that the hazard was overestimated, in comparison to what the drivers consider as serious danger, e.g. warning for dangerous declivity may be underestimated as a hazardous point, if the driver passes safely without special care by this point.

4) Finally, no assistance method or system warns and protects from danger that is caused by other reasons besides the above mentioned ones. Example of factors that are not included as danger parameters are:

* the human factor (e.g. hazard due to lack of education of an area or country drivers),
* local customs or habits (e.g. holidays, manifestations etc.),
* the time for passing from one point (e.g. some point of the road network becomes dangerous at night due to lack of road markings, where no danger exists during the day),
* the weather conditions (e.g. some point of the road network becomes dangerous during rain, such as passage by torrent bridges etc.),
* unpredicted factors causing which accidents at some areas without any particular reason.

According to the present service, locations, sections or areas of the road network (that can also be countries) are statistically examined as to the number, the causes, the time and the conditions of the observed accidents during a recent period of time (e.g. the last 5 years). The examined accidents are classified with respect to several factors such as:

* Accident's seriousness degree (deadly, light etc.),
* Type of vehicles where the accident occurred,

* Personal data of the drivers who experienced the accident,
* Cause of accidents such as improper passing, excessive speed, slippery road, transversal kind, unknown reasons etc.,
* Accident's time of occurrence (month, day, time) and comparison to similar manifestations of the same period (e.g. Athenians exit for Easter, Frenchmen exit to Spain during holidays, Germans exit for Weinfest in Munich, etc.),

and other factors such as the subjective estimation of accident's cause, vehicle's age, damages that were caused etc.

Additionally, locations of the road network which present a hazard even though increased number of accidents has not been observed are examined. Examples of such locations are, the section of an interstate passing through an urban area, points of minor collisions in urban centres, dangerous declivities in case of snow fall, long straight sections of interstate where there is danger of drowsiness etc. After classification of these elements, they are registered into the data base and for each part of the course the hazardous characteristics of each section of the road network (see embodiment's description). Upon the vehicle's entrance in a course's segment between two nodes, depending on the registered elements, the driver is notified e.g. for number of accidents which occurred at this part, for seriousness of accidents which have occurred, for causes of accidents etc. In case the accidents' causes present uniformity, the driver is notified acoustically, visually or by touching, for manoeuvres that would minimise the chance of accident e.g. warning for speed reduction or warning for not passing another car. Finally, in case of accidents at some area, due to weather or seasonal phenomena, such as rain fall, holidays and other, the driver is notified acoustically, visually or by touching when the weather or seasonal conditions coincide with conditions when the accidents

occurred.

The main advantages of the present service are:

1) The protection and control are provided depending on real observed elements and not on just possibilities.

2) They offer to the driver more ways of avoiding accidents besides simply warning for attention and lower speed such as

* avoidance of passing other vehicles
* granting of priority
* preference of traffic lane
* use of special devices such as chains
* imposition of special head lights use etc.

3) The driver's informing for real observed accidents, such as "at this course section that you just entered, 34 deadly accidents occurred during the last 5 years", result in driver's alerting even though he does not detect any danger at that point at the moment of passing.

4) Finally, the driver is informed about all factors that influence safe driving during passing by some location, and not only about limited number of factors. Examples are the following:

* Information about the skill and the driving habits of the inhabitants during passing by some foreign country,
* Temporal or local events that must be taken under consideration as factors of accidents e.g. holidays, local events etc.

5) The driver is informed about the possibility of an accident, based on statistic calculations, when the accidents factors are similar to the ones concerning the specific vehicle. Therefore, in case of a sequence of turns, only drivers of vehicles with towed vehicle are

warned for overturning accidents that happened in the area. In case of accidents which occurred at night, only the drivers that pass by that area at night are warned. The same is valid for accidents due to e.g. snow fall where the warning is supplied during the winter only and not during the summer.

6) The service warns for accidents which occur without visible or specific causes, so that the driver's alerting is based on actual data.

7) The service takes under consideration specific facts that actually occurred, and not specific factors for the drivers' protection. This way, the method is more successful in preventing accidents compared to methods that only warn for possibility of danger's existence.

8) Finally, the statistic study of road accidents is used by the vehicle's routing service for determining e.g. of a safer course from origin to destination, which statistically contains lower number of recorded accidents.

Two ways of embodiment of the present service are foreseen. According to the first embodiment, at every part of the course, data concerning statistic accidents are registered, which occurred at a certain period of time. The entry of this data performed in the following sequence:

(a) First the data concerning accidents at some part of a thoroughfare between two nodes are collected and classified. The classification must be the same for all accidents and road networks of application of the proposed assistance system. A classification embodiment is the following [Figure (105)]:

1) Depending to the seriousness' degree, e.g. deadly, seriously injured, slightly injured, serious material damages, slight material damages.

2) Type of vehicles where the accident occurred, e.g. passenger vehicles, trucks, buses etc.
3) Cause of accidents as irregular passing, improper change of lane, excessive speed, unknown reasons etc.
4) Accident's time determination (month, day, time).
5) Weather conditions (rain, ice, snow, wind, fog etc.).
6) General observations, such as drivers' mentality and habits, defective equipment, road works etc.
7) Hazardous locations without large number of accidents.

In the spirit of the invention is also included any other type of classification.

(b) Every classification group or sub-group is assigned a code name (e.g. a combination of letters, or numbers). This code number is allocated to the data base through some form, sound or signal, so that it can be transmitted to the driver by all three ways of communication.

An example of such embodiment is the connection of the code of the first classification group to some figure. According to figure (105) the deadly accidents' code number corresponds to a cross figure, the seriously injured accidents' code with a T figure, the slightly injured accidents' code with an E figure, while the damages with an L figure. The acoustic correspondence is for e.g. deadly accidents a bell sound, serious accidents a siren sound, for slight ones a telephone ring, for damages a hammer's sound etc.

A similar acoustic or schematic representation is performed for the codes of the other classification groups as well. This connection is one way and concerns every part of the road and every accident which is registered and classified by the system. For visual representation of accidents, colors are assigned such as e.g. for deadly accidents the black is assigned, for serious injury the red, for slight injury the yellow, and for material damages the

blue color. A similar visual representation is performed for the other classification groups or sub-groups. Another embodiment of visual representation for the first group of accidents is e.g. for deadly accident the picture of a coffin, for serious injury the picture of a red cross, for slight injury the picture of a blue cross, and for material damages the picture of a hammer. Hence, for representation of the data for a part of the course corresponding to 5 deadly accidents, 5 with slight injuries, and 15 with material damages only, are shown on the screen 5 coffins, 5 blue crosses and 15 hammers.

(c) The allocation of the accidents' statistics data at every part of a course between two nodes is performed as follows [Figure (106)]:

First, the code numbers of the first and last node, and the course's Iength between the two nodes are registered [Figure (106)]. For every noted accident the type accompanied by its code number (e.g. serious injury), the distance from the initial node where the accident occurred, the vehicle's type code, the cause's code etc. follow until the codes classification completion. The next accident type (e.g. deadly accident), the accident type's code, the vehicle type's code, the accident cause's code etc. follow. Figure (106) shows such a data base structure.

According to a first embodiment, the accidents' data consist a special unity from the other data of the road network (e.g. topography, traffic signs etc.). According to a second embodiment they are included into the traffic signs' data (e.g. with information about areas and buildings on both sides of the road network), and according to a third embodiment they are included into the topographic data of the road network, so that they are combined with driver's guidance. This way, during the vehicle's passing from a course's segment between two nodes, the driver is notified for dangerous locations visually, acoustically, or by

touching, for accidents which have occurred during some period of time at the course's segments.

According to a second embodiment of this service, at the courses' segments between two nodes, brief statistic elements are registered declaring the danger's level of this course's part. Such brief statistic elements are:

1) A number of a ten degree danger scale, with numbers ranging from 0 to 10.
2) A code number declaring the number of the most serious accidents which have occurred in one area, e.g. 10 accidents with serious injuries.
3) A code number declaring the number main causes of accidents which have occurred in an area, e.g. 15 accidents due to illegal passing.
4) A code number declaring the time of the most serious accidents.
5) A code number declaring the weather conditions of the most serious accidents.
6) A code number declaring the observations of various factors that affected the most serious accidents.
Every combination of the above is considered in the spirit of the invention.

An example of such registration at the data base is figure (107), where the same codes and acoustical, visual or by touching signals are used, as in the case of the first embodiment of the detailed registration of the hazardous locations. According to figure (107) every part of the course is characterised by the origin node, the destination node, the distance between the two nodes and all the above mentioned codes or only some of them.

The brief description of the road network's hazardous locations, occupies a separate space in the data base. But according to another embodiment it is registered together with the road network's data (topography, traffic signs

etc.)

84. Timely Guidance to Drivers

A service where information are registered in the data base of the processing system, concerning the area where the vehicle moves in but having limited duration, changing during a period, and been defined by the use of an external transmitters network of long range, which enter directly to the data base, information and data in fixed periods of time, thus supplying the driver with timely information. A system for supplying timely information is based on a central station in the vehicle's movement area, which informs the drivers for matters of interest to them. The capability of the driver for communication with the central station and request of information is also foreseen. Another system through the vehicle's radio, adds timely messages to the regular radio broadcasting.

Main disadvantages of these information systems are the following:

1) They require installation of a complicated and very expensive central station for collection and supply of information. Usually they are organisations employing many people.

2) The procedures of information is time consuming, especially for the systems where the driver communicates with the central station in order to request information.

3) The transmitted information by these stations regard mainly traffic matters and rarely information of different nature.

4) These stations transmit mainly general information regarding a wide area where the vehicle moves (e.g. information about the town where the central station is installed). Therefore, no information is provided for matters that regard another place (e.g. a small country town).

According to the present service the following are foreseen:

Automated stations transmit timely informations without any or with minimum requirements in e.g. maintenance personnel. These automated stations are placed at every area which the system covers e.g. neighborhoods, country towns etc. These automated stations transmit a variety of information of interest to drivers and other users as well, e.g. drug stores and gas stations which are open all night, ferry-boats itinerary, beginning or termination of traffic restrictions etc., which are characterised by variation of time during short or long periods of time.

Before the transmission of any group of information, as for drug stores which stay open all night, a typical code number precedes which characterises the type of information that will follow. The code messages which follow consist the information that interest the driver. These information are provided periodically e.g. every 5 min. and are continuously updated. Registration of these data at the on-board system's data base is done without driver's knowledge or by warning without his active participation. The advantages of this service are:

1) Very expensive installation of the station is not required.
2) It is not a time consuming process.
3) It covers a wide range of information similar to information provided by telephone services.
4) They may service any number of places due to easy installation.
5) The supplied data are at the disposal of the data processing system, therefore they can be a parameter for all the services that the system foresees (e.g. determination of course to the closest drugstore which is open all night).
6) The supplied information are directly at the driver's disposal without asking for them.
7) Due to encoded transmission, the messages of the

automated stations can be transmitted at any frequency of the E/M radiation, without using already dedicated frequencies.

8) The transmissions are brief and repeated so that reception is ensured by the vehicle's receiver.

A typical code number, unique for the group that is related to, precedes every group of timely information. The general system structure has already been described and is not mentioned here. The system's receiver [Chapter d - Para (32)], upon reception of the typical signal, carries it to the processing system where a data recording program is activated, and at a proper format for the above data, e.g. different format of recording is foreseen for the drugstores that stay open all night, and another for ferry-boats itinerary. Following the above procedure, the data that follow are entered into the data base for later use by the driver. An example of such timely information signals reception is shown in figure (108).

85. Device for Vehicle's Immediate Immobilisation

General

The capability of immediate immobilisation of a moving vessel or vehicle, is a method of protection against immediate danger. Besides protection, often immobilisation of a vessel or vehicle is required for a limited period of time. Such case is the immobilisation of military aircrafts at limited landing length on aircraft carriers or limited runway length. In this case, a hook is attached on the aircraft and a wire on the aircraft carrier's landing site is held by the aircraft's hook when it touches the runway and it holds it at the limited area that is available.

The system which is presented here, concerns vehicles moving on the ground and mainly concerns protection by immediate danger.

Presentation of the Device

A device which is installed at every vehicle type, is controlled by the data processing system and is activated in case of emergency, when vehicle immobilisation with the brakes is insufficient or impossible. This device allows the vehicle's immobilisation at a specific distance from its activation point, where the distance is automatically selected according to the device's design, relatively to the vehicle's speed and the vehicle's deceleration which can be tolerated by the passengers. This distance for a particular vehicle speed is always constant, regardless of the road surface's quality, the weather conditions (rain, ice), the tires' quality, the suspension's quality or the driver's physical condition.

The device includes a mechanism for the launching of a sharp spike. The spike is launched towards the ground, with initial kinetic energy such that its thrusting can be assured into any road surface [Figure (109)]. The spike is connected at its other end, to a holding thread, which in a first embodiment is wire rope of sufficient cross section, for the secure holding and deceleration of the vehicle and in a second embodiment is elastic thread of high strength and low elasticity module. In Figure (109), a wire rope is shown as holding thread. Finally, the device foresees a thread unwinding mechanism, in a way that the vehicle be immobilised at a specific distance from the launching point of the spike.

In figure (109), the arrangement of a wire rope's unwinding mechanism is shown, which has a braking mechanism, consisting of a spring for progressive increase of the vehicle's holding force, and hence, progressive vehicle's deceleration. Analytical description of the device is provided after the presentation of the characteristics and advantages.

The device's characteristics, which are also advantages, are:

(a) It permits the vehicle's immediate immobilisation at any environmental conditions and any slippery road condition. Most of the accidents could have been avoided if, at any conditions, a capability of vehicle's immediate immobilisation existed.

(b) The automated activation of the immediate immobilisation system, by the processing system, guarantees the driver's safety against accidents due to the driver's bad physical condition, when the driver is unable to perform correct manoeuvres or avoid immediate danger.

(c) This device is the only guarantee to the driver's safety in case of a sudden increase of road slip, as in case of ice. In such cases, lack of this device is fatal, and any other means is useless concerning the driver's safety.

(d) Similarly, this is the only device which can hold the vehicle on or near the road surface in case of either an accident or improper maneuver. Most of the accidents are caused by vehicles going off the road and colliding or fall at buildings or places at both sides of the road.

(e) Finally, it is the only device which guarantees avoiding of accident, when a sudden obstacle appears during the vehicle's course, such as e.g. sudden appearance of a pedestrian, vehicle, animal etc.

Specifically, this device consists of three partial mechanisms [Figure (109)]:

1) Spike launching mechanism
2) Holding thread unwinding mechanism
3) Activation mechanism

More analytical:

1) The holding spike launching mechanism is the mechanism which provides the spike with sufficient energy in order to

be thrusted into any road surface type. This energy, is provided to the spike, according to a first embodiment, by:

- explosive charge

according to a second embodiment by:

- compressed spring of high elasticity measure

according to a third embodiment by:

- pressurised air reservoir

which is provided periodically by a pump only during vehicle's motion, for a period of time sufficient for storage of the required compression energy.

A similar mechanism is employed for the spring's compression by energy supplied by the vehicle's engine. This way, according to the second and third embodiments, the energy which is required for spike shooting and thrusting into the ground, is supplied to the device when the vehicle's engine is on, and not continuously. Hence, if the vehicle is stopped or undergoing maintenance operations, the shooting mechanism is not charged and therefore it does not consist a danger due to e.g. accidental activation.

The device's usefulness is the following:

Practically, the driver during motion, has only two mechanisms in his/her disposal for his/her protection.

* the braking mechanism
* the steering mechanism

Both of them are practically of low importance at high speeds and conditions of increased slip or low visibility, and especially for reacting to an immediate danger. In the above cases, use of the steering mechanism will have the opposite results from the desired ones. A vehicle in such a situation is practically unprotected. Furthermore, it is well established,that most of the deadly accidents occur under such circumstances.

The above mentioned vehicle's immediate immobilisation device consists an additional absolutely safe mechanism, which manually, instinctively or automatically by the processing system, guarantees protection where the common mechanisms are insufficient or dangerous if are not used properly. The energy sum, which must be stored, is calculated by the energy, required for the spike's thrusting to a sufficient depth into the road surface, in order to hold firmly the vehicle. An example of the energy calculation is provided below:

* <u>Experimental results</u> show that, for the thrusting of a 16mm diameter spike, into an average ground, in 300 mm depth, the required energy is:

$$E = 6500 \text{ N.m}$$

The experimental arrangement is shown in figure (110) and consists of a vertical rail where a mass M can roll, by the use of rollers: $M = 25$ kg

This body carries an indicator, which shows the height where the mass M is found at every moment on a ruler. The height measurement ruler is attached to the rail. At the bottom part of the mass a vertical spike is attached. The mass is always risen at a specific height (H) from the ground surface and the height, which the indicator shows when the mass is allowed to fall on the ground, is measured from that reference point.

This height H1, if multiplied by the weight (Mg), shows the energy required for the spike's thrusting in depth (Δh). From this energy, the amount consumed by the friction forces between the rollers and the rail is deducted. The amount of this energy loss is calculated if the body falls on a spring of a known constant k [Figure (111)]. From the spring deflection, the energy, which it has absorbed is found. This energy is compared to the spring's potential energy (M*H1*g). The energy difference is the friction energy.

The formulas which apply here, are:

- Energy produced by the mass M: $E\alpha = M\ H1\ g$
- Energy supplied to the spring: $Es = 1/2\ k\ (\Delta h)^2$
- Friction energy: $Ef = E\alpha - Es$

The following were measured:

- k = spring constant = 13500 N/m
- $H1 = 2.95$ m
- $\Delta h = 0.28$ m
- $M = 25$ kg

Therefore:

$$Ef = E\alpha - Es = M\ H1\ g-(1/2)\ k\ (\Delta h)^2 =$$

$$25kg(2.95m)(9.81m/sec^2) - (1/2)(13500N/m)(0.28)^2m^2$$
$$Ef = 105.4\ N.m$$

By measurements about the thrusting energy the following results were produced:

A spike of 16 mm diameter and a body of mass M = 25 kg, at a height H = 2.0 m were used. The following heights H1 and thrusting depths Δh were measured [Table (12)]. From this table, the energy per cm of thrusting into the ground is selected equal to:

.......Joules/cm

The spike's thrusting depth which is required depends on the ground and the transversal force which is required to hold. The experimental arrangement which was used, is shown in figure (112). The spike is thrusted into a predefined depth Δh every time, whereas a spike height ho is still protruding over the ground's surface. At the spike's free edge, the edge of a strain wire rope is attached, and is strained by a

GROUND TYPE	H1(m)	Δh(cm)	Energy per cm of thrusting (MH1g-Ef)/Δh
Ground without gravel	1.88	12	
Ground with gravel	1.85	10.5	
Asphalt (1)	1.83	8	
Asphalt road surface	1.82	7.3	
Urban road surface (1)	1.83	8.1	
Urban road surface (2)	1.82	7.4	
Interstate's surface (1)	1.81	7.1	
Interstate's surface (2)	1.82	8.2	
Runway road surface	1.80	6.1	

TABLE (12)

strain mechanism. A spring of a known factor k is attached somewhere intermediate of the wire rope for the measurement of the force which is applied on the free edge of the spike. A length measuring device, fastened on the wire rope winding drum, measures the winded length of the wire rope and therefore the length of the spring tension. From $F = k.f$ (where k is the spring constant and f the elongation, the applied force F on the spike's edge is determined. From the vehicle's geometry, i.e. height H (winding), height ho (free spike height) and length l (between spike and strain mechanism), the wire rope's angle φ relatively to the horizontal is possible to be determined and therefore the applied on the spike force F can be analysed to horizontal and vertical component Fh and Fv.

From these forces, the horizontal component Fh is mostly of interest for practical use in vehicles. For use of the device on other types of vehicles (e.g. aircrafts on runways) the vertical component Fv must be taken into account for the proper thrusting depth determination. From the measurements, the table (13) was filled. By this table, a thrusting depth of 150 cm is selected. In conjunction to the results of the previous table, a total energy is found for the spike's thrusting equal to ......Joules. For the method's first embodiment, according to which the spike is launched by the use of explosive charge, the required characteristics of the explosive material are determined as follows [Figure (113)]:

<u>Symbols</u>

P (Kp/cm^2) Pressure of gases:
- Po (initial explosion pressure)
- $P\tau$ (final exit's pressure)

V(cm^3) Volume of gases:
- Vo (initial charge's volume)
- $V\tau$ (final barrel volume)

GROUND TYPE	SPIKE'S THRUSTING DEPTH D = 16mm						
	10cm	15cm	20cm	25cm	30cm	35cm	40cm
Ground without gravel							
Ground with gravel							
Asphalt (1)							
Asphalt road surface							
Urban road surface (1)							
Urban road surface (2)							
Interstate surface (1)							
Interstate surface (2)							
Runway road surface							

TABLE (13) - Relation between depth and maximum holding force for various ground types

For adiabatic expansion:

$$E = \int_o^T P.dV = Po.Vo^{\gamma}\int_o^T \frac{dV}{V^{\gamma}} = \frac{Po.Vo}{100(\gamma-1)}\left[1 - \left(\frac{Vo}{V\tau}\right)^{\gamma-1}\right]$$

where γ = 1.4 isentropic change coefficient.

Example of calculation:

$$Po.Vo = \frac{E.100\ (\gamma-1)}{1-(Vo/V\tau)^{\gamma-1}}$$

For a given explosion pressure Po, the required volume Vo of the explosive charge may be calculated. The same formula applies also for the case of use of compressed air for the spike's shooting. For a given volume Vo of the air container, the required gauge pressure for the spike's thrusting into the ground results, according to the method's third embodiment. According to the method's second embodiment, i.e. by use of a spring, the energy stored into the spring is given by the formula:

$$Es = (1/200)k.f^2$$

where k = the spring constant in Kp/cm
f = spring's deflection in cm
Es= energy stored into the spring

From the formula, the spring's constant k, therefore the spring that will be used results, if the Es (thrusting energy) and the spring deflection f are known. Hence, for f=20cm ⟶ $K = 200Es/f^2$

2) The thread and the holding mechanism aim at decelerating the vehicle at a tolerable rate for the passengers. For the transverse deceleration, as tolerable for the passengers

value is selected $\gamma=3g$, where $g=9.81$ m/sec². For this deceleration value, if M is the vehicle's mass, the resulting deceleration is:

$$Q = M\gamma = 3Mg$$

The force Q must be less than the maximum holding force of the spike, which is shown in table (13) and depends on the thrusting depth and the ground type. From this deceleration force, the length for the vehicle's immobilisation results. This length is determined by the relation vehicle's kinetic energy = deceleration force's work:

$$(1/2)\ M\upsilon^2 = Q.S \longrightarrow S = M\upsilon^2/(2Q)$$

e.g. for vehicle's and passengers' mass M=1100Kg, vehicle's speed $\upsilon=80$ km/hr = 22.2 m/sec, $\gamma=3g=3.981$ m/sec² results:

$$S\ (m) = (1/2)[M(kg)\upsilon(m/sec)]/Q(Nt)$$

$$(1/2)[M(kg)\upsilon(m/sec)]/[M(kg)3g(m/sec^2)]$$

$$S\ (m) = (1/2)\upsilon(m/sec)/3g(m/sec) = 8.37\ m$$

For vehicles of different types (weight) and different speed, the following deceleration forces and immobilisation distances result, for given $\gamma = 3g$ (m/sec²) deceleration rate.

The thread and the deceleration mechanism are shown in figure (114). The holding wire rope is fastened on the spike's edge, and is winded around the unwinding drum, which is supported and fastened on two bearings. On the unwinding drum's axis the disc of a discbrake is fastened. The discbrake pads are fastened on the vehicle's frame, and compress the disc with a vertical force which depends on the desired deceleration force. The discbrake pads are compressed on the disc with the aid of a screw so that they

always apply a vertical force.

An example of a vertical force for drum diameter $D\tau$ = 30 cm, radius of pads' range R6 = 10 cm and for desired holding force $Q=M.\gamma$ (where M=1000Kg and $\gamma=3g=3x9.81\ m/sec^2$).

3) The shooting mechanism's activation is performed manually by the driver, when he/she detects immediate danger and by the data processing system, when by the data of the on-board devices and the topographic data which are registered in the memory unit, it detects immediate danger which cannot be avoided by use of the brakes or any maneuver, e.g. at a crossroad, when the system receives the code of an oncoming vehicle violating priority, this device is the ultimate means of protection from an oncoming accident.

So, as mentioned, the method offers:

* information
* communication
* control
* precaution
* protection

for avoiding of traffic accidents due to:

a) local weather phenomena
b) bad vehicle's condition
c) bad positioning or improper maneuvers
d) bad driver condition

Besides these services, if the processing system detects inability of the driver to avoid an oncoming accident, it activates the device, thus immobilising the vehicle, thus employing the ultimate means of protection of the vehicle and the driver.

Variations and applications of the device

1) The unwinding drum's axis is connected, via a gearbox, to an electric motor, which rotates the drum opposite to the direction of unwinding. According to this variation [Figure (115)], upon the electric motor's starting, the discbrake is disengaged. In figure (115), the winding and launching drum and the discbrake with the frame's releasing mechanism, are shown. Furthermore, the gearbox and the rewinding motor are shown. This variation allows the vehicle's displacement via the wire rope's winding, in case that its displacement with the motor's power only is impossible. Such cases are:

* Vehicle release from entrapment on ice, mud, water etc.
* Retrieval of vehicle after falling off the road.
* Retrieval of vehicle from a slippery declivity.
* Retrieval of another vehicle by its mooring to the wire rope.

The same rewinding mechanism is also used for the spike's retraction from the ground.

It has been mentioned that the spike is mostly used for the application of the transversal force Fh, for holding the vehicle and not of the longitudinal force Fv [Figure (112)]. Practically, the longitudinal force Fv is significantly small in relation to Fh. Therefore, if the wire rope, according to the variation, is winded around the drum, and the vehicle is pulled near and finally over the spike, the winding force is sufficient for pulling the spike off the ground, allowing the vehicle to continue its course.

2) According to a second variation, the reuse of the spike is foreseen. According to this variation the winding mechanism is maintained, as shown in figure (116) of the previous variation. This mechanism is combined with a shooting mechanism via a spring. This variation is shown in

figure (116). According to this second variation, the wire rope passes through the barrel or two position rollers, and then it is directed towards the winding and unwinding mechanism of the previous variation. Due to this modulation, the motor rewinds the wire rope to the winding drum, and at the same time guides the spike into the barrel. There, it compresses the spring until it comes at the trigger's arming position. At this position, the discbrake's pads are not activated, but only in a fraction of a second, after a new spike shooting, so that the holding force will not reduce the spring's thrust for the spike thrusting into the ground.

This variation allows for reusing the system countless times. Besides the usual advantages of such an arrangement, the system's application is reported here as an auxiliary driving mechanism for special cases e.g. acrobats shows, criminal's pursuing through the city, racing on irregular roads, jungles, deserts etc.

3) This device is placed on any type of vehicle, which is in danger, and demand immediate immobilisation. Therefore, this device can be placed on aircrafts too, for their immobilisation on the runway, during taking off or landing, when a danger arises. For the case of aircrafts installation of more than one device for immediate immobilisation is foreseen. This device installed on aircrafts allows for its immobilisation and protection, in cases of emergency landings on irregular grounds, in cases of landing system's damage, etc.

f. DRIVING METHODS

86. Automatic Determination of Maximum and Minimum Speed

This service refers to the setting and preservation of the vehicle's proper speed, depending on the road network data or the vehicle type, which is characterised by the supply of

directions to the driver, about the pressure applied on the accelerator, so that the vehicle maintains the proper speed, while the driver is able to either reduce speed by pressing the brakes or increase speed by pressing the accelerator, but no more than a predetermined by the microcomputer, value. A well-known system which is installed on vehicles with automatic transmission, enables the driver to accelerate the vehicle to some speed and then by activation of an automatic mechanism, to maintain this constant speed. The vehicle's speed is maintained constant until the driver presses the brakes and the speed's preservation ceases. However, if the automatic mechanism is again activated, the vehicle's previously adjusted speed is restored (Cruise Control).

<u>Disadvantages</u> of this automated speed adjustment are the following:

1) The speed is selected once by the driver and remains the same even if the road network data change. For new speed's adjustment the speed's setting the driver is again required.
2) If the speed is reduced by use of the brakes, driver's action is required for restoration of the speed's automatic adjustment mechanism.
3) The system cannot be applied to road networks which require frequent increase and decrease of the speed limit, or into urban areas because it is extremely inconvenient and dangerous.

In view of the above mentioned, the microcomputer of the present service is capable of predetermining the proper vehicle speed, by the road network data and the vehicle type. For vehicles supplied with automatic transmission, by the use of the accelerator only, the vehicle reaches this speed and preserves it constant thereafter. Two ways of using this service are foreseen. According to the first one, the vehicle's acceleration until the proper, for every course section, speed is performed by the microcomputer and

instructions are provided for this limit attainment. The task of the vehicle's deceleration is all that is left for the driver. According to the second way the microcomputer, depending on the road network data, checks the speed only for its value, and prevents any violation of the present speed limit. The driver controls the acceleration or deceleration, but he/she is not allowed to violate the speed limit. This second embodiment is the only existing for vehicles without automatic transmission.

The main <u>advantages</u> of the present service are the following:

1) Relieves the driver from the continuous search for the proper speed or the continuous increase decrease of the vehicle speed, by continuous use of the accelerator and brakes.

2) It is particularly useful to the new or apprentice drivers because it relieves them from one serious task.

3) It is especially useful to movement in unknown areas (foreign countries, provincial roads), where the driver is not aware of the speed limit at every moment.

4) It reduces significantly the driver's fatigue.

5) The driver has the capability to set as maximum speed a percentage of the indicated by the microcomputer, when his/her physical condition does not allow high speed travelling. (e.g. when he/she feels tired, requests by the microcomputer the setting of a lower instead of an optimum speed limit).

The main sections that embody the service are [Figure (117)]:

* The vehicle's data processing system.
* The data base that supplies the processing system.
* The odometer, where its indication is entered as a continuous data in the processing system.
* The peripherals for supply of directions to the driver.

The data base connection to the processing system or the data base's contents, are described in Chapter b. The odometer and its connection to the processing system are described in Chapter a - Para (4). The supply of directions is done visually, acoustically and by the touching device, as described in Chapter d. From the road network data and the vehicle type, the microcomputer calculates the optimum vehicle speed. According to the first way of this service's application (where the processing system controls the vehicle's acceleration) the microcomputer checks the number of pulses in a specific period of time, by the indications of the odometer, and it calculates the vehicle speed. If the vehicle speed is lower than the desired one, the microcomputer notifies the driver to accelerate. When the vehicle speed approaches or exceeds the proper value, the microcomputer notifies the driver to apply the brakes etc.

87. Guidance for Sport Driving (Racing)

This service assists vehicle drivers which participate at racings and is characterised by the vehicle's supply with two additional wheels for measuring the travelled distance or vehicle's turn, in a way that every change of the vehicle's position or speed on the racing track, be registered by the two wheels' odometer indications or their angle of turn, so that through them information be given for the drivers' assistance. None of the examined drivers' assistance systems or methods makes any reference to racing drivers. For the autonomous systems, this is due to the insufficient accuracy of the vehicle's position estimation by the usual methods, and particulars, the exact racing cars position, where the driving techniques impose extreme friction conditions between the tires and the ground resulting in tires slipping instead of rolling for a major part of the course (departure, turns) and the vehicle's longitudinal axis, usually at turns, to be inclined with respect to the road axis. Hence, significant errors enter the identification of the vehicle's position or direction.

Consequently, every guidance effort would consist of supply of directions at improper time, creating hazards, than favors to the drivers. At the depended systems, the vehicle's position depends on and is identified by externally installed infrastructure (usually, transmitter's system), so the driving type does not affect the vehicle's position estimation. However, the transmitters' network can identify only the transmitter's area where the vehicle is at and not its exact position. Therefore, again the provided services do not have the accuracy which a rally requires, since usually the driver's reactions require accuracy of a fraction of a second.

For the present invention, the exact position estimation of a vehicle, slipping or not, is performed by measuring of the travelled distance of the two wheels and the angle of turn. These two wheels [Figure (118)] are firmly attached on two points under the vehicle, and through a spring's mechanism they are continuously in contact with the ground, even if the vehicle slips or loses contact with the road surface. This way, the two wheels measure exactly the position and speed of the vehicle's two points (the points where the wheels are attached). Since these two wheels do not participate to the vehicle's thrust and steering, they determine its position and kinematic condition with great reliability. Therefore, the data and instructions supply at the proper time, becomes reliable to the vehicles drivers at rallies.

The main advantages of this service are the following:

1) The addition of the two auxiliary wheels and the sensors for distance and angle of turn measurement, is easy and not expensive.

2) The said sensors and their assembly to the vehicle's processing system, do not depend on vehicle's parts or mechanisms, which are strained during racing (e.g. wheels, steering wheel etc.).

3) It is extremely accurate and provides data for extraction of various vehicle motion's parameters by the use of a minimal number of additional mechanisms.

4) The principle of this method, modified, is applied on other transportation means and not only ground vehicles.

5) Operation of the measurement systems is assured even if the vehicle slips or loses contact with the ground.

Description of the main parts which embody the rotating wheel's service [Figure (118)] is given below:

The wheel (1) rotates around axis (9), which is parallel to the road's (11) plane, i.e. the plane of wheel (1) is vertical to the plane of road (11). The wheel's (1) axis (9) is attached on solid (2). Solid (2) can be rotated by axis (4) around the solid (3). Axis (1) is vertical to the wheel's (1) axis (9). Solid (3) can be rotated about the support (10) through axis (5). Axis (5) is parallel to the wheel's (1) axis (9). The support (10) is attached on the vehicle. The spring (6), pulls solid (3) and assures the continuous contact of wheel (1) with the road surface (11). Sensor (7), measures the angle which the solid (2) creates upon its rotation, in relation to the vehicle's plane of symmetry. Sensor (8), measures the wheel (1) rotations, in relation to solid (2).

The vehicle's position estimation method by use of two rotating wheels, is shown in figure (119). Initially, a coordinate system XOY is defined, where axis OY, at the moment of the measurements beginning coincides with the vehicle's motion direction, consequently $\theta_{10}=\theta_{20}=0$, $x_{10}=x_{20}=0$. (The two rotating wheels are placed such that solids (3) are on the vehicle's plane of symmetry and axes (4) have a distance l).

Since the intervals (S1, S2) and the deviation angles (ω1, ω2) of the rotating wheels are continuously measured, we are able by use of a computer, to calculate the exact position

of the vehicle's points 1, 2, with coordinates (X1, Y1) and (X2, Y2), as described in detail in figure (119). Furthermore, the deviation (σ) which is formed by the vector l with respect to OY is also found.

The above mentioned method is especially useful to vehicles with intense slip, such as vehicles that are used at rallies, ice sledges, tanks, hovercrafts etc. Furthermore, during slip we know the slip rate (dy/dt, dx/dt), and although at rallies the use of the two wheels is prohibited, it is allowed at the test drives. For reliable driving the driver must get sufficient information e.g. wind, tires' wear, power, brakes condition etc. Actually, the vehicle's position estimation method is identical to the one which is used for the vehicle's position estimation by the use of odometer and directional wheels' angle of turn [Figure (36)]. The difference of this method, concerns the determination of the curvature radius by the angle of turn of the measuring wheels, whereas the travelled distance is measured by the measuring wheels also.

Notice: Practically, two auxiliary wheels transversal angle sensors are required (one for each wheel) but only one odometer.

Since the curvature radius of the vehicle's trajectory (or the instantaneous centre of rotation) are defined by the auxiliary wheels' transversal angle, measurement of the motion of one vehicle point suffices, for the exact vehicle's position estimation. Figure (120) presents the algorithm of the vehicle's position estimation by the use of two wheels.

88. Vehicle's Parking at a Limited space between Vehicles

The present method provides the driver an assistance service for parking at a limited space, i.e. space between two

already parked vehicles or generally space which requires manoeuvres of the vehicle for its entrance to the parking space. For this service, the odometer is required [Chapter a - Para (4)] for determination of the longitudinal available distance, and then a mathematic analysis of the vehicle's motion is done by the use of figure's (121) or (122) equations, for the case of a towed vehicle, for the determination of the directional wheels' angle [Chapter a - Para (5)], at every part of the course. The driver is notified acoustically, visually or by touching for the required manoeuvres at every moment. The known parking assistance systems have:

(a) a sensor off the vehicle, which warns, by a characteristic sound, when it approaches the sidewalk or other vehicle.

(b) radar for the same purpose.

Their disadvantages are:

(a) They do not know if the empty space between two vehicles suffices.

(b) By the oblique positions that the vehicle gets during the parking manoeuvres and due to the different height of the sidewalks and the vehicles themselves, any sensors possibly installed do not always find their target.

(c) They do not guide the driver as to the required manoeuvres.

(d) The driver is required to try to see backward and at the same time forward.

(e) Finally, all manoeuvres remain at the driver's judgment, who usually does not estimate correctly the distances. As a result many collisions usually occur at parking.

The present system includes:

1) Length measurement sensor (odometer).

2) Directional wheels' angle of turn sensor.
3) Relative hardware for these data collection [Chapter a - Para (1)].
4) Algorithm which

   a) Includes the vehicle's length and the wheels' position in relation to the vehicle.
   b) Includes the vehicle's width.
   c) Calculates the vehicle's x-y coordinates in combination to the wheel's turn.
   d) Guides the driver to park the vehicle at very limited areas with few maneuvers.
   e) Keeps in the microcomputer's memory parking types for places known to the driver.
   f) Keeps in the microcomputer's memory maneuvers from difficult courses at limited areas, yards, circular parking ramps, either by forward or backward movement or a combination [Formulas of Figure (121)]
   g) Receives information externally transmitted, e.g. at a parking entrance it gives the whole course, floor, exact position or even the way that the vehicle should park, at ports, railway stations, factories etc. guides all incoming trucks, supplies vehicles etc. to their destination.
   h) Appears the vehicles on a screen and monitors the parking procedure.
   i) Has a device that supplies the parking with the course and the parking location, through special wiring.
   j) Guides for maneuvers, special kinds of vehicles (e.g. U-Hauls) [Types of Figure (122)].
   k) Besides the acoustical and visual notification for the vehicle's position, in relation to the other two vehicles, there is also the device for proper course's indication, which was described in Chapter d - Para (45).

The present system operates with combination of the steering

wheel's and the odometer pulses, for obtaining of the proper directions specification for parking (mostly with reverse). Initially, the vehicle is driven at the first parked vehicle's level. There, the driver presses the measurement key, which can be the same with the calibration key, which, when it is pressed, e.g. twice, it does not "forget" the road meters and starts measuring for parking. Then the vehicle is driven until it reaches the rear level of the second vehicle and again the driver presses the key (twice) so that the distance can be exactly measured, whereas the data processing system determines if the space suffices for the specific vehicle's parking and if the parking is possible with the first or second attempt. Then, the driver starts the vehicle and as soon as some message is heard e.g. STOP, he shifts to reverse gear and starts again. The vehicle moves backwards for a few meters, at a steering wheel's angle x, which is calculated by turning the steering wheel until another message is heard, e.g. STOP. At some location during reverse movement, a STOP message is announced, directions are provided about the steering wheel's angle and reverse motion starts until ARRIVAL is announced.

The programming is possible to be performed by copying the exit maneuvers from the parking. Hence, by turning the steering wheel all the way, the vehicle exits from the same parking space without many maneuvers. The same happens for parking, i.e. where a maneuver is needed for entrance or exit, it is copied and executed reversely.

SERVICE'S EMBODIMENT

(a) The vehicle's driver is notified visually, acoustically or by the touch device, to press the A1 key upon passing next to vehicles A and B for parking [Figure (123)], where vehicles A and B determine the available parking space. The key is pressed e.g. upon the front bumper's passing by the front bumper of the forward parked vehicle [Figure (123)].

The disposed parking length A is thus registered by the processing system [Figure (121)]. At the same time, the pressing of the A1 key [Figure (123)] defines the odometer's measurement start. Upon pressing the key, the vehicle's position relatively to the disposed parking area is determined.

(b) After the pressing of the key for the parking space size determination, the processing system notifies the driver to drive the vehicle at the side and at a safety distance d from the front parked vehicle, e.g. 0.5 m.

(c) The vehicle's geometric dimensions have already been registered in the system's memory unit, i.e. length L, width B, wheel base M and track rear S. Furthermore, the maximum angle of the directional wheels' transversal turn θmax, which corresponds to the minimum curvature radius ρmin is given. Naturally, the driver is asked to define if the vehicle parks to the right or left of the road. The algorithm structure is shown in figure (124).

(d) The following preliminary calculations are executed by the processing system [Figure (124)].

$$\rho = M/\tan\theta - S/2$$

where ρ = curvature radius, M = wheel base ,S = track rear and θ = directional wheels' angle of turn.

$\rho\ \omega = \Delta l$, where Δl = travelled distance, ω = angle and ρ = curvature radius [Figure (125)].

Checks:

θmax = maximum angle of turn of directional wheels

$$\rho_{min} = \frac{M}{\tan\theta max} - \frac{S}{2} \quad \text{minimum trajectory radius}$$

$$A-\varepsilon = 2\rho_{min} \cos\omega \longrightarrow \omega = \cos^{-1}[(A-\varepsilon)/2\rho_{min}]$$

$$2(\rho_{min} - \rho_{min}\cos\omega) \begin{cases} > B+d \\ = B+d \\ < B+d \end{cases}$$

$> B+d$, $= B+d$: only 1 parking maneuver is required

$< B+d$: more maneuvers are required

1) $2(\rho_{min} - \rho_{min}\cos\omega) = B+d$

Instructions from Position 1 :

* Steering wheel's complete turn (right),
* Backwards by $\Delta l = \rho_{min}\ \omega$,
* Steering wheel's complete turn (left),
* Backwards by $\Delta l = \rho_{min}\ \omega$

2) $2(\rho_{min} - \rho_{min}\cos\omega) > B+d$

Calculations

$2\rho \sin\omega = A - \varepsilon$

$2\rho(1-\cos\omega) = B+d$

$$\left.\begin{aligned} \rho \sin\omega &= (A-\varepsilon)/2 \\ \rho \cos\omega &= (B+d)/2 - \rho \end{aligned}\right\} \quad 2\rho^2 = [(A-\varepsilon)/2]^2 + [(B+d)/2 - \rho]^2$$

$$\rho = \ldots. , \quad \omega = \sin^{-1}\frac{A-\varepsilon}{2\rho}, \qquad \tan\theta = \frac{M}{\rho + S/2}$$

Instructions from Position 1:

* Directional wheels' angle of turn θ (right),
* Backward course by $\rho\ \omega$,
* Directional wheels' angle of turn θ (left),
* Backward course by $\rho\ \omega$

3) $2(\rho_{min} - \rho_{min}\cos\omega) < B+d$

Instructions from Position 1 (more than one manoeuvres are

required) [Figure (126)]:

Manoeuvre A'

* Steering wheel's complete turn (right)
* Backwards by $\rho\ \omega$
* Steering wheel's complete turn (left)
* Backwards by $\rho\ \omega$

Transversal distance $B+d - 2(\rho_{min} - \rho_{min} \cos\omega) = D$

Manoeuvre B'

* Steering wheel's turn by 0° (straight)
* Forward movement by $(A-L-d\varepsilon)$

Calculations:

$$\omega = \sin^{-1} [(A-L-d\varepsilon)/2\rho_{min}]$$

$$2\rho_{min}\ (1-\cos\omega) \begin{cases} > D \\ = D \end{cases} \text{one more manoeuvre is required}$$

$$2\rho_{min}\ (1-\cos\omega) < D \quad \text{more manoeuvres are required}$$

Steps 1), 2), 3) are repeated, where instead of M+d and A-ε, D and A-L-ε-dε are used instead.

In Figure (127) a parking example is shown, where the microcomputer's instructions are followed as closely as possible, where the microcomputer continuously calculates the steering wheel's angle of turn and corrects the driver's possible mistakes.

89. Guidance under Specifications

According to this service, certain specifications are set by the driver or automatically (under specific circumstances), concerning guidance supplied to the driver, and required manoeuvres.

These specifications correspond to e.g.:

* High vehicle's average speed,
* High accelerations and decelerations,
* A special way of turn's accomplishment, e.g. the use of the brakes and the accelerator at the same time),
* Special type of manoeuvres (slight understeering, oversteering etc.)

During guidance, accurate instructions are supplied to the driver and not simple directions e.g. "Brake - Acceleration- Steering wheel's turn 60° - Acceleration - Gear shift" etc. In the spirit of the above service, guidance for maneuvers originating by some individual's experience (e.g. race driver) or some driving school, are included.

This way, accumulated driving experience is transmitted and employed, through this method, by each individual. Similarly, the service is used for driving learning or as assistance to beginners. In this case, every maneuver is explained and analysed afterwards, so that its meaning be understood by the apprentice driver. In some cases (e.g. after many hours of driving, during the night, etc.) guidance under specifications is automatically selected, since it does not exhaust the driver by:

* Driving at low speed

* Driving without abrupt accelerations, decelerations etc.

This service completes the routing under specifications (easy - economical - fast) and opens a new dimension to driving. According to another embodiment, the special characteristics of each individual's driving type are registered into the memory unit (e.g. very fast driving, often use of the brakes) and the services are accordingly adjusted to him.

90. Guidance in Unmapped Areas (Harbours, Factory Yards)

This service assists in movement through areas which are not covered by or do not have a road network. Such areas are e.g. harbors' docks, warehouses, factories, commercial exhibition centres, tourist areas, large parking etc.. The service concerns the assistance of transport companies, truck drivers, taxi drivers, travellers etc. Despite the fact that these areas are not part of the road network, another element that impedes guidance and routing, is the fact that their structure is continuously changed according to the amount of the exhibits, the areas of approach of the vessels, the available space etc.

According to an embodiment of this service, the said vehicle parks at a specific space in a specific area and at a specific direction. The map of the area, as it is arranged during the vehicle's arrival is then externally fed into the memory. Consequently, the point where the vehicle is heading is entered as destination to the site plan (e.g. loading dock 15). On the site plan map areas where the vehicle can move freely, are shown. Then, a guidance program is formed for these areas, which is provided in the form of instructions for accurate manoeuvres towards the desired destination, e.g. "Straight 150m - Left turn 30° - Straight 200m - STOP". This is obtained by the microcomputer, by laying out a course through the allowable areas and afterwards by driver's guidance for the course attendance.

g. REGISTERING DANGEROUS SITUATIONS

91. Highly Protected Memory Unit (Black Box)

A device which consists of electronic solid memory unit, highly protected against mechanic, thermal, chemical, etc. stress, where certain data are registered, concerning the

last period of time or travelled distance, data which the microcomputer processes and which are capable of totally simulating the driving conditions during the last sections of a course. In case that an accident is confirmed, the data are registered in a memory part, which cannot be erased by the driver. It is therefore used for simulation of accident conditions.

A state-of-the-art system is acknowledged under the brand name DRACO from B. Fincham, M. Fowkes & P. Willson (see "Advance Telematics in Road Transport" Proceedings of the DRIVE Conference Vol. II, Brussels 4-6 Feb 1991). This system also consists of a memory unit, where vehicle's motion data are registered during the last interval of its motion. For the vehicle's collision and therefore accident detection, 4 accelerometers are employed, one for each of the main axis x, y, z and one for the angular acceleration about the vertical axis. A combination of the indications of these accelerometers can be a criterion for collision and accident detection.

In this case, the registered data concerning the vehicle's motion are stored in a special location in the memory unit for future reading. For taking into account any possible mistake, the last five recordings, which resulted from accident's indication by the accelerometers, are kept in the form of files. The registered data are mainly the vehicle's speed and the accelerometers' indications during the last part of the course. Its main disadvantages are:

(a) High cost of embodiment and programming due to the combined use of the accelerometers for tracking of accident and driving conditions.

(b) Insufficient information because from the registered data, the overall driver's compliance to the traffic regulations and traffic signs is missing. Only vehicle's movement data are registered, without any reference to external factors.

(c) The system is independent. Therefore, it lacks part of the support which it could have, if combined with a driver's guidance or assistance system.

(d) It mainly describes in detail the events after the accident and not the conditions that led to the accident.

It was stated previously that it consists of a solid memory unit, highly protected against thermal, mechanic, chemical, and other stresses. In this memory unit, the topographic and motion data which the microcomputer processes during the last e.g. minutes of the course or during the latest travelled distance, are continuously recorded. In case that an abrupt change in the odometer's and directional wheels transversal angle sensor's indications is detected, the data are registered in another part of the memory for future reading. A high capacity is foreseen for filing of many (e.g. 100) groups of data for the last part of the course.

The advantages of the device and method employed here are:

(a) It is simple and is applied easily.

(b) It supplies a multitude of data which can accurately represent the conditions just before an accident.

(c) It cooperates with a vehicle's routing, navigation and information system, so that in general, its operation is more economic.

(d) It does not require the use of accelerometers or other devices (besides the odometer and the transversal angle sensor) for tracking of an accident.

(e) It is generally economic.

According to a first embodiment, this device consists of a solid memory unit, where data are maintained, which the microcomputer accepts, processes and transmits during the last period of travel time (e.g. the last 10 seconds) or during the last course's distance (e.g. the last 150 meters). This solid memory unit is highly protected against mechanic, thermal, chemical or other stress.

In figure (128) this memory unit is shown. The software which is related to this memory includes:

* Capability of storage of the vehicle's latest position in the memory where it can be recalled from at any time,so that entry of the initial position is not required each time.
* Capability of storage of data and information regarding the vehicle's course and maneuvers, in order to be used as evidence in case of e.g. accident, emergency, theft etc.

More specifically, this device consists of a solid memory unit which communicates with the vehicle's data processing system through a terminal cable. This solid memory unit is enclosed by:

- A layer of elastic material for the vibrations' absorption.
- High standard's thermal insulation of high thermal conductivity coefficient.
- External layer of high strength material for mechanical and chemical stresses (e.g. stainless steel Cr Mg).

In the spirit of the invention is also the solid memory unit's encasing with any other texture's material, for protection against other stresses besides the thermal, chemical and insulating. Such encasing could be e.g. from lead for protection from ionising radiation and generally protection from any field effects which could alter the contents of the solid memory. Applications and characteristics of this protected memory unit are mostly the ones which regard the determination of accidents' conditions, and especially accidents, where all vehicles involved carry a similar device, allowing thus the determination of the accident's responsible party.

The great advantage of the present method is the following:

Usually for the determination of drivers' responsibility at

accidents, the driver's compliance to the traffic regulations is taken under consideration. However, this is not really fair, since in order to avoid an accident, caused by another driver's improper maneuver, the specific driver hardly cares for the traffic regulations. Instead, he concentrates in the immediate danger. In most cases the drivers, in their attempt to protect others or be protected from other drivers' reckless driving, are forced in violation of traffic regulations, in causing accidents, where they are considered guilty because of lack of determination of the guilty part. An example of such case is shown in Figure (129) where the exit of vehicle B from a transversal road and a STOP sign violation, forced vehicle A to a maneuver and collision with an unsuspecting vehicle C. In this case driver A is sentenced, whereas the real responsible party A will escape any responsibility for the accident.

By this method and to a first embodiment, the indications of the wheels rotations measurement devices and the directional wheels transversal angle device, and the road network's topographic data and its auxiliary data (such as traffic signs, lights etc.) are registered. Therefore, it is possible for the last part of the course, to be determined:

* If the wheels stopped at a STOP sign. This is succeeded by comparison of the odometer's indications (which must be zero for a period of time) versus the topographic indication of a STOP sign existence.
* If the vehicle's speed was correct in relation to the speed limit. This is succeeded by comparison of the odometer's indications in the unit of time, in relation to the imposed one by the topographic data.
* If the vehicle's speed was reduced where this is imposed by topographic data e.g. pedestrians' crossing.
* If a turn was executed, where the topographic data prohibit it, by examination of the directional wheels transversal angle measuring device's indication.

Similarly, the following can be determined:

* Errors during driving or in parking position,
* Improper stop,
* No use of the directional lights,
* Irregular vehicle's passing,
* White line's crossing,
* Execution of turn at high speed,
* Time of collision. This is certified by the abrupt change of the wheels rotation or steering wheel's transversal angle indications,
* Traffic light violation, etc.

According to an embodiment, the recording into the memory unit of the traffic violations along with the location of their occurrence (e.g. entrance node, exit node, distance from entrance node), is foreseen. Practically, this device connected by a therminal connection, to a data processing system, similar to the on-board system, reproduces the conditions prevailing during the last course minutes or meters. This way, the driver's reactions during the critical moments, before the accident, are shown, and of course the responsibilities' attribution is more fair.

By introducing the capability to totally control the driving conditions, this device introduces more fair criteria for responsibilities' attribution and has a direct effect on the drivers' insurance and protection method. Furthermore, due to the fact that it only records a short (negligible) part of the course duration, it does not violate the drivers' personal life. It is expected, also to affect the way driving is considered by the drivers, i.e. they are expected to show higher responsibility, since now there is a capability of checking not only about participation in but also about causing of accidents. Particularly, for drivers under influence of alcohol, anger etc., the device easily detects and registers their condition as explained in the relative section [Chapter e - Para (54)].

The data which are continuously registered in the memory unit are only the absolutely necessary for reproduction of the conditions during the last part of the course. These data are:

1) Entrance node's code of the course's part where the vehicle moves at.
2) Exit node's code of the course's part.
3) Distance from the entrance node at any time (by the odometer's indications).
4) Vehicle's speed, during the last part of the course.
5) Steering wheel's turn angle indication, during the last part.
6) 0-1 indications for non use or use of the instruments which the driver handles e.g. horn, direction lights, head lights, handbrake, electronic horn [Chapter e - Para (79)].
7) Vehicle's identification.

These data are sufficient to totally reproduce the last part of the course therefore the conditions that led to the accident. Therefore, by the indication of entrance-exit nodes and the travelled distance from the entrance node, the topographic data, the road network data, the traffic signs etc., can be simulated. By the vehicle speed and the directional wheels' angle, certain conclusions can be drawn, about maneuvers on the road network, about the vehicle speed and position, whereas the 0-1 indications for use or non use of the instruments that the driver handles, provide a more complete picture of his/her behavior.

A comparison of all driver's actions, with respect to the road network data, show the accuracy of his/her actions or not. For the reading of these data, a device similar to the vehicle's processing system is used, for reproduction of the conditions which led to the data recording.

92. Warning in case of Collision

A service for detection of a vehicle's collision. Detection is performed by two methods:

(a) By the use of an accelerometer which detects high deceleration values.
(b) By the tracking of abrupt change and sudden interruption of the odometer's and directional wheels sensor indications.

After the collision's detection, the driving conditions during the course's last period of time or distance, are initially registered, and then an on-board transmitter is activated, which transmits an encoded message which is read by systems on passing vehicles as "Attention - Collision" warning the drivers for the chance of collision on the already collided vehicles. The message, in another embodiment, consists of transmission of a characteristic sound (BEEP) of increasing frequency, as the distance to the collision location decreases.

93. Alarm in Case of Theft

This service concerns the vehicle's protection in case of theft, and is embodied by an autonomous transmitter embodied in the vehicle's frame. By the term "autonomous" its energy autonomy is signified, which is succeeded by use of a strong battery, which is charged during vehicle's normal operation, just like the vehicle's usual battery.

The transmitter is activated:

(a) When the vehicle's motor is turned on,
(b) When the vehicle is moved by any way (e.g. use of accelerometer),

and is adjusted to transmit, with a delay of e.g. 3 min.,

the repeated encoded signal, which corresponds to "Attention - Car Theft with data e.g. red ALFA ROMEO .....". In order for the transmitter not to transmit, during the delay period, some code number must be entered into the vehicle's processing system e. g. by the vehicle owner.

94. Vehicle's Speed Recording

According to this service, the instantaneous vehicle speed is recorded e.g. every 100 meters of course, and is kept, e.g. for checking in a special memory unit or part of the unit. It concerns special types of vehicles e.g. public trucks, school buses etc.) for controlling the drivers' and other vehicles' safety, and for statistic studies as well.

95. Traffic Violations Recording

According to this service, the driver's traffic violations are recorded, compared to the traffic regulations or the proper driving rules e. g. STOP sign violation, illegal parking, speed limit violation etc., along with some additional data, such as the time that the violation took place, the location etc. For this service's embodiment, the registered in the memory data concerning traffic signs are compared to the vehicle's motion data and any deviations are recorded.

96. Statistics for Reckless Driving

According to this service, statistic data concerning each drivers' way of driving are recorded in a special unit or a special non-accessible location in the memory unit. Therefore, e.g. average driver's violations for every week, the frequency of the speed limit's violation, the frequency of abrupt deceleration (braking), abrupt course changes, frequency of attention distraction etc. These statistic data are used for checking drivers of special vehicles (e.g. school buses, public transportation etc.), and for

modification of guidance instructions depending on the driver.

97. Table of Warnings

A table where various data of interest to drivers are recorded, for trip programming or for a course checking. These data, according to a first embodiment, are the average course speed, the average fuel consumption, the estimated time of arrival, the time, the date, the driving hazard level, the vehicle's general condition etc.

h. INFORMATION

98. Guidance for Driving over/under Bridges

Information service concerning passing over or under bridges. Particularly, the geometrical and other useful data regarding bridges (e.g. maximum weight, road surface quality, road width, bridge height) are stored in the memory unit during mapping. The vehicle's geometrical data (e.g. width, height) are already provided to the data processing system, which is capable of determining the safety or not of the vehicle's passing under the bridge, by comparison of the vehicle's height versus the bridge height, and the safety or not of the vehicle's passing over the bridge, by comparison of the, continuously monitored, vehicle weight versus the maximum allowed weight, as provided by the bridge specifications. Furthermore, the system compares the vehicle's width with the minimum available road surface width.

When approaching a bridge, the data processing system recalls from the memory unit standardised messages, and transmits them to the driver (e.g. "Attention! Uneven road surface", "Do not change lane on the bridge", "Maximum weight 3 tons", "Attention! Lane merging"). In case the system detects possible danger, the driver is informed

accordingly, by audio or visual messages or by the touching device (e.g. "STOP! Low bridge", "Danger! Overweight vehicle").

99. Programming of Meetings and Stops

(a) Programming of Meetings

The driver types the destination and desired time of arrival, (e.g. location A, time 10:15 p.m.). The system is capable of providing the following service:

At any instant, the data processing system monitors and verifies the exact location of the vehicle on the road network, as it was described in Chapter d - Para (35)-(38). At regular time intervals, the system determines the shortest course from its occasional position to the previously specified destination, and it estimates the time required for timely arrival at the predefined destination. The main feature of the present service is the fact that the system alerts the driver and guides him/her towards a predetermined route to the final destination, when the system, at some location, estimates that the time available will barely suffice. Furthermore, the driver is advised by the system not to follow a certain course if that will take him/her beyond the time constraing, which he/she has specified.

The present service is particularly useful in cases of travelling in areas with time-varying road-network data, or through rotating bridges, or in cases of using ferries and transporter ships, where the driver ought to be on time for passing or boarding.

(b) Programming of Stops

The microcomputer accepts the following data:

* initial vehicle's position,

* intermediate stops location.

The arrival time is provided also to the system along with each stop, if necessary. The waiting time at each stop is also provided, if necessary. The microcomputer determines one or more alternative routes from the origin to the first (timewise) destination. The routes are selected by the microcomputer in such a way, that arrival to the first destination will be timely. Subsequently, the waiting time is taken into account and a new route is selected by the microcomputer, towards the second stop in such a way, that arrival is also timely. The second stop selection usually coincides with the second (timewise) required stop.

However, if a different stop (e.g. the fifth) is found to be very close to the first stop and if the predefined sequence of stops does not guarantee the timely arrival at the fifth stop, then the microcomputer will change the stops sequence, in order to satisfy all the time constraints. Hence, following the first stop, it selects the next stop, determines the route (or routes) towards the second stop and determines the timely or not arrival. The process is repeated for the third stop and so forth.

(c) Other Services

1) Memory storage of certain routes and their recall by the driver.

The microcomputer, taking into account the present vehicle position, determines the course towards the nearest (timewise) recalled route point and it follows the remaining route section till the destination location. In a variation of the previous service, the destination location is provided along with a few nodes that the vehicle must intercept during its course towards the destination location. This feature is particularly useful when determining a course towards not easily accessible or

underdeveloped areas, where the driver prefers transportation to a destination via a certain, safe or interesting road.

2) Recording of an occasionally followed course.

According to this service follows a course which is recorded by the microcomputer as a sequence of nodes. The driver has the option to request from the vehicle's data processing system the recording of the previous e.g. 25 nodes, or the sequence of the nodes starting from a previous location of the followed course, assigning a name to the course for its future recall.

This service is particularly useful when the driver seeks an unknown location at some area, e.g. parking area, where upon finding of the searched location, the course is registered in the microcomputer's memory unit for future use. Also, when during travelling in touristic areas, a certain route presents particular interest for the driver, he/she records it for future reuse or for suggesting it to other drivers. Finally, the present service is particularly useful in cases of unexpected changes at the road network data, such as bridge collapsing or detour due to road works. The driver then, simply inserts the detour information in the system's memory unit.

3) Routing services during driving in urban centers, which serve the traffic management, are described in detail in Chapter c - Para (23), which concerns the traffic management service.

4) When the driver follows a predetermined course, the microcomputer monitors continuously the vehicle's position and examines if it agrees with the recorded course. If at a certain location the system determines that there is a deviation from the predetermined course, the microcomputer determines a course that will take the vehicle back to the

originally predetermined course.

In another variation of the previous service, the driver voluntarily ignores the predetermined course. He/she has then the following two options:

(i) To follow a detour and, at a certain location, to request by the microcomputer restoration to the initial course. The microcomputer then draws a new course, from its present location towards either the initial deviation location or the nearest node of the previously abandoned course.

(ii) To interrupt the monitoring of the followed course at the detour location, and to retrieve the course monitoring upon its return to the detour location.

100. Mailing List

Information service concerning registration of certain destinations in the system's memory unit, where the destinations are easily retrieved from the memory, by typing or tracing a simple number, which is the sequence number of the memory allocation where each destination is registered. Each destination is determined by street and number, last name, building operation (e.g. Ministry of Finance, St. Sophia Cathedral, Karaiskaki Soccer Stadium) or by the node code number.

Through this service, the driver registers the most commonly used destination locations, in order to select his/her destination at the beginning of each course, by a simple and quick process (e.g. menu selection, typing of a two-digit number). So, the driver selects from a range of 99 numbers the number 13, which corresponds to e.g. Democritus Research Center, and the system announces, audio-visually, the selected destination, the driver verifies by pressing the appropriate key, and the processing system initiates the

routing towards the selected destination.

101. Touristic and Commercial Applications

Driver information service concerning specific buildings, services, archaeological sites, entertainment etc., aiming at facilitation of driver in his/her professional affairs, mainly in remote or unfamiliar areas (e.g. trader, salesman, insurance agent), facilitation of tourism, mainly in foreign countries where communication barriers exist. Trips to unknown areas, either neighboring or distant, satisfy the human need for greater communication, knowledge and entertainment, but they always include some degree of adversity, caused by communication difficulties, parking, destination determination, adverse weather etc.

Through this service, the driver is informed, in the language of his choice, about useful data concerning the visited area (e.g. historic, cultural, financial, political and other data), the inhabitants, useful buildings (e.g. Hospitals, Hotels, Banks, Embassies, Restaurants, Drugstores, Gas stations, Auto repair shops, Chambers, Public Services, Archaeological sites).

In Chapter c, it has already been mentioned that the driver has the option of selecting the Touristic course towards a destination, and that results in a routing that will guide the vehicle near all area sites or buildings, which present some touristic interest. By approaching one of these sites or buildings, the data processing system recalls from the memory unit all the appropriate information, providing a "touristic guide" service. All that information is registered in the system's memory unit at the beginning of the trip or upon entering into the visited country (whenever the trip regards a different country).

The present information service allows for the tourist, trader, salesman, representative, insurance man, technician

and in general any professional, to proceed in opening his professional range by servicing customers from previously unknown to him or remote areas, not been affected by his ignorance of the road network, by adverse weather, late time etc.

102. Calendar

Information service concerning the registration in the memory unit of the meetings schedule for a certain period, the automatic reminding to the driver at properer time and automatic routing for timely transportation to the corresponding destinations. The time period which the meetings schedule can cover, could be a few hours, a day, a week, a month etc. This reminding service is presently offered by a secretary or an organiser. In this case the advantage is that the informations are provided without been requested, and until the scheduling is cancelled, the system will perform routing towards the specific destinations, and it will alert the driver about the time available.

So, according to this service, the driver starts his/her daily course towards his/her work, he/she is informed that in 30 min he/she must participate in a meeting in the Ministry of Transportation, and he/she is asked if the meeting has been cancelled. If the driver's answer is negative (e.g. type N for NO) the system proceeds in routing towards the preprogrammed destination.

G. IMPLEMENTATION

EXAMPLE OF APPLICATION OF THE METHOD

Mr. A. wishes to travel with his car, from the city that he lives at to the capital of the neighboring country, on a business trip. He will have two business meetings at 1000 am on the 23rd and at 300 pm on the 25th.

On the 10th of the present month Mr. A. enters his vehicle, activates the microcomputer which controlls the devices that implement the system of AUTOMATIC ROUTING, GUIDANCE, PROTECTION and INFORMATION, which his vehicle is equipped with. For activation, Mr. A. simply cranks the engine. The system is automatically activated through the electrical circuit of the vehicle. Mr. A. hears and sees on the system display the following message:

"PLEASE TYPE YOUR CODE NUMBER"

Mr. A. employs the touching device for message transmission and traces on the device the following characters:

I.Z.U.X.D.-

which constitute his personal code number. The system can identify 3 code number formations, Mr. A's, his wife's and his older son's. In case the system does not identify one of the three code number, or if the above process is not followed, or if the system is disconnected, then 15 seconds later, a well protected in the vehicle's frame, autonomous transmitter is activated and the following message is transmitted:

"ARREST THE DRIVER OF THIS VEHICLE, IY9060 RED ALFA 33".

The modulation of this message allows for its reception from a similar system or from the traffic police, or from a local network of security transmitters/receivers, which is installed in most large cities and which has been funded by local insurance agencies. Furthermore, the system retrieves from memory the registered data regarding the driver. From them it is concluded that Mr. A. is a young entrepreneur 59 years old. He usually drives very early in the morning and very late in the evening. Statistically, he drives smoothly, with average speed and avoids sudden accelerations or deccelerations. He violates the traffic regulations about twice every 10 km. During driving, he is very often absent-minded, with an average frequency of 9 times every 10 km.

Data concerning the vehicle are also registered in the memory unit. So, it is known that the vehicle frequently experiences loss of power, overturning and it usually requires a long distance for complete immobilisation. Naturally, besides the statistical data, the memory unit contains all the vehicle's geometrical characteristics.

At the system's display the following message appears: "Mr. A. DO YOU WISH A ROUTING?", which is also announced to Mr. A. by the system's speaker. Each system's question is escorted by a direction regarding the key to be pressed or the character to be traced at the touching device, for an answer. For the previous message, the system explains:

YES - Trace Y or press 4
NO - Trace N or press 5

Mr. A. traces Y on the touching device. Then the following message appears:

"TRACE DESTINATION CITY AT TOUCHING DEVICE:
Mr. A. traces: D.U.S.S.E.L.D.O.R.F.-

"TRACE ADDRESS"
Mr. A. traces: P.E.T.E.R.S.S.T.R.A.S.S.E.-2.5.-

Following the directions, Mr. A. finally enters his two meetings and the exact time that they will take place.

The system announces:

"ENTER DISKETTES A-14, E-38 AND C-44 FOR ROUTING"
Mr. A. has the following diskettes from previous trips:

A-14, which contains his country's network
E-38, which contains the continent's interstate network, and
C-44, which contains the local network of the city which he will visit.

Following the directions he inserts the diskettes in a sequence and he waits. In 4 minutes three alternative routings appear. For the determination of these routings the system combines:

- The road network data
- Mr. A.'s personal data
- The vehicle's data
- The dates of the planned trip

Hence, because the trip is done at early spring, and some mountainways are still covered withe snow, easier routes were selected and, in two instances, country roads instead of interstates (Autobahus), were selected. Routes with sharp turns and urban centers' passing were generally avoided (when possible). Gas refill stops were programmed and a list of certain tasks was defined.

Therefore, Mr. A. was informed that, before the trips starts, he should:

- Replace the right rear tire that was worn out
- Check the braking system
- Balance the left front tire
- Check the electric system, and
- Identify the cause of the frequent pressure loss from the left rear tire.

Mr. A. was also advised not to load his vehicle with more than 550 kgs. From the study of Mr. A.'s personal data and his driving habits statistics, it was concluded that driving should stop for the driver's rest every few hours. For example, the first course includes:
1st part - 5 hours drive and 2 hours rest
2nd part - 4 hours drive and overnight rest
3rd part - 6 hours drive and 2 hours rest
4th part - 3 hours drive and arrival at city
5th part - Overnight rest and arrival at first destination

Moreover, for frequent alerting of Mr. A., routes passing near archaeological sites and industrial zones are selected.

Finally from the road network data, Mr. A. is informed the following, concerning the first course:

* Course length 3,456 km
* Average programmed speed 110 km/hr
  - Minimum programmed speed 50 km/hr
  - Maximum programmed speed 160 km/hr
* Gasoline consumption 350 liters
* 10 stops at gas stations
* 1 engine oil change
* Passing through 3 nations
* Passing through 12 and near 34 cities
* Travelling along 1,452 km of interstate of quality A, 956 km of interstate of quality B, 400 km of country road, 648 km of city roads
* Encounter of 56 hazardous locations where accidents occur frequently
* 450 STOP signs, 235 SPEED LIMIT signs, 56 bridges, 9 tunnels
* 59 acclivities, 48 declivities, 556 turns of small curvature radius
* 30 cities of archaeological interest, 5 tourist resorts
* Departure date the 21st of the month, at 8.00 am.

Similar data appear for the next two courses.

Mr. A. selects the second course, which resembles the first one, but includes fewer hazardous spots. Next, Mr. A. registers the course to a separate diskette, where the surrounding road network is also registered, for use when deviating from the course. Mr. A. places all diskettes in their box and turns the system off. In the morning of the 18th, Mr. A. listens to and sees on the screen the following message:

"Mr. A. - press 8"

By pressing 8, Mr. A. is informed about the programmed trip. The system retains only the departure date and the pre-trip tasks. Hence, the task list is repeated.

- Replace the right rear tire that is worn out
- Check the braking system, etc.

Mr. A. presses initialisation and he receives audio-visually, the following message:

"Mr. A. DO YOU WISH A ROUTING?"
Mr. A. traces N on the touching device and then, following the directions, he traces:
"A.L.F.A.-R.O.M.E.O.-R.E.P.A.I.R.-S.H.O.P.-" and then:
"N.E.A.R.B.Y.-"
The system, automatically, selects the nearest (timewise) auto repair shop.

Mr. A. is wearing a large "watch" on his right hand and on its lower surface, which is in contact with his skin, small pins are arranged. This is of course the touching device for wireless message reception. On this device, Mr. A. "senses" the formation of the following figure, through a sequential pressure by the little pins.

```
o——>o——>o
^
|
o
^
|
o
```

At the same instant, he receives the audio-visual direction "TURN RIGHT" and then "ACCELERATE-BRAKE-STOP-CHECK-TURN etc.". At the same instant the right group of blinkers starts lighting sequentially,

```
o——>o——>o——>o
```

at a slow rate, which accelerates as the vehicle approaches the turn. Ten meters ahead of the turn both groups of blinkers start blinking warning Mr. A. to stop. The names of the streets that Mr. A. moves on, or he will turn to, appear on the display and fight before the intersection the STOP sign appears.

A schematic map appears on the display and the suggested course is shown outlined. Already the first part of the course before the turn is shown with a different color, indicating travelled distance. Right at the turn, a sound (BEEP) verifies the turning. Then the new direction is given by the touching device:

```
o
^
|
o
^
|
o
```

The two extreme blinkers of each group start blinking and the following warning is transmitted by the speaker:

"STRAIGHT-MODERATE ACCELERATION-SPEED LIMIT 30 km/hr-APPROACHING TRAFFIC LIGHTS-BRAKE-CHECK TRAFFIC LIGHT". The traffic signs for this course section (30 km/hr, ATTENTION PEDESTRIAN CROSSING) and the three big lights, green, yellow, red (approaching a traffic light) appear on the display. At the same time, the thick red line towards the traffic lights changes to green, to denote travelled distance.

The speaker sound and the blinkers warn Mr. A. to reduce speed when approaching the traffic lights. Indeed, since the traffic light programming is registered in the system's memory unit, Mr. A. is warned that the light will be red at the traffic light passing. In any case a visual inspection direction is provided. It is already too late when Mr. A.

realises that the light is red. He steps hard on the brakes, the wheels lock and the vehicle slides for 3 meters before it is completely immobilised. Therefore, Mr. A. heard the sound (BEEP) 3 meters away from the traffic lights, instead of hearing it at the traffic lights for position verification. Mr. A. remembers and presses "Initialisation" informing the processing system for the existence of error in the estimation of vehicle's position. But even if he did not remember, the ECHO-TRANSMISSION system would redetermine the vehicle's current position, be reference to the city's buildings. Furthermore, the position would be estimated by the traffic signs, the road inclination, the curvature, the passing by a gas station and of course by reaching an intersection or turn, where the pressing of "INITIALIZE" or simply the turning would restore the correct position of the vehicle. Just in case, the system's receiver would determine the exact vehicle's position by receiving a signal from the network of transmitters.

Mr. A. did not conceive any of the position verification methods nor did he realise that he did not turn, following the next message, and of course he did not realise that the system performed rerouting to another auto repair shop, which was closer due to the deviation. He only realised that he entered a degradated area full of narrow streets and that the guidance signs were more complicated. Hence, the touching device showed symbols such as:

```
            o                  o<--o<--o<--o
            ^                              ^
            |                              |
o-->o-->o-->o                              o
^                                          ^
|                                          |
o                                  o-->o-->o
^                                  ^
|                                  |
o                                  o
```

and at the same time the following audio directions were provided:

"STRAIGHT-RIGHT AND IMMEDIATELY LEFT-LEFT-STRAIGHT FOR TWO BLOCKS-RIGHT".

Whereas on the display, no street signs were shown and the "new" thick, red line was going to change color, meaning that Mr. A. was approaching the destination.

The fact is that another misfortune had happened. The vehicle's receiver had received a sequence of code numbers representing the streets which were congested. Hence, the selected course, through the narrow streets, by passed two of these streets, that could lead Mr. A. to his destination. The destination, a car repair shop, was depicted behind a gate, which was guarded by a guard at his office, and consisted of a vast area full of boxes, cars, trucks and control kiosks.

Mr. A. explained the purpose of his visit to the guard, who pressed a few keys on a device and handed Mr. A. a diskette. Mr. A. inserted the diskette (which contained the route to be followed towards the vehicle examination point), the gate opened exactly at the location where two poitioning tapes and a transversal verification cable existed, Mr. A. passed through the two tapes, stopped on the verification cable with the rear wheels, and followed the directions:

"STRAIGHT-BRAKE-STOP-STEERING WHEEL 1/2 TURN RIGHT-STOP-STRAIGHT-ACCELERATE-STEERING WHEEL LEFT etc."

Similar signals were received by the touching device and the blinkers. The course indicator, a moving indicator representing the vehicle position and a frame representing the proper course margins, appeared on the display. Mr. A. had only to maintain the indicator inside the frame, by proper driving.

Suddenly, the message "ARRIVAL" was transmitted. An employee guided Mr. A. to park between two boxes. Mr. A. pressed the 9 key, while driving, and passing by the two boxes, he pressed the key "INITIALISE" right at each passing, and then he followed the system's parking guidance. Before he finally exits his car, he supplied the system with a temporary password, namely "1-5-8-4-3", for a limited range of 5 km, and 36 hrs, for the exclusive use of the repair shop personnel. After that period expired, the system would request one of the three legitimate code numbers.

On the 21st, Mr. A.'s journey for his professional meetings started. The SYSTEM OF AUTOMATIC ROUTING, NAVIGATION, PROTECTION and INFORMATION, guides Mr. A. to the nearest gas station and then presents the recorded data from the first route part:

- LENGTH: 334 km
- AVERAGE SPEED: 105 km/hr
- MAXIMUM PERMISSIBLE SPEED: 130 km/hr
- MINIMUM PERMISSIBLE SPEED: 55 km/hr
- SPECIFIED MILEAGE: 30 lt
- PASSING BY TWO MULTILEVELLED NODES etc.

From Mr. A.'s trip the following were recorded in the system's memory unit:

- 35 violations of the traffic law and common-sense driving
- 2 warnings for low pressure tires. In one of them the system, automatically, guided Mr. A. to a repair shop.
- 1 warning for overweighted vehicle
- 10 warnings for slippery road
- 2 warnings for strong wind

Finally, 5 warnings to Mr. A. were recorded, concerning reckless driving, probably due to sleepiness, and one activation of the vehicle's immobilisation device. The

conditions that activated the device were the following:

The expressway allowed for a speed limit of 120 km/hr. However, the system warned for a speed reduction due to approaching to an unattended railway crossing. Mr. A.:

- Ignored the audio warning for speed reduction
- Ignored the blinkers' signal calling for a stop
- Ignored the display signal for approach to an unattended railway crossing
- Ignored the hazard indication by the touching device
- Ignored the electronic horn activation, warning nearby drivers for reckless driving
- Ignored the automatic activation of parking lights.

Therefore, 50 meters ahead of the crossing, the immobilisation spike was activated. Mr. A. felt a violent vibration, whilst 3 vehicles stopped cautiously next to him warned by the electronic horn. One of them belonged to the local police. Apart from these, it was a pleasant trip.

- Mr. A. enjoyed guidance through a complex node. The system warned him about positioning the vehicle at the proper lane, whereas the course to be followed was provided to him by shape, acoustically and visually.
- He was warned automatically to turn the vehicle's lights on, during passing through the first tunnel.
- He enjoyed a mountain ride which he programmed for guidance for sport driving.
- He was awed each time the touching device transmitted a cross, meaning that he was passing the location of a deadly accident.
- He wondered at the archaeological sites he encountered during his course, listening to the registered information each time.

Finally on the night of the 22nd, he finally arrived at the city of his destination. The vehicle's receiver had

received a transmission of contemporary information, which, among others, contained the code numbers of all the hotels that had vacancies. After an automatic check versus the registered information, the system proposed to Mr. A. 7 hotels. Mr. A. selected the third one, which happened to be the nearest and the vehicle guided him to the hotel parking, via audio, visual and by touching guidance. Before he exits the car, he raised the volume of the vehicle's transmitter and set the system on surveillance mode.

Mr. A. woke up at 5 a.m. on the 23rd in his hotel room. It took him some time to realise that the touching device, which was permanently under his watch was transmitting an alert signal. Somebody had moved his vehicle and the theft alarm had been activated. The hotel manager assured him that the car had been moved near the entrance, where it had been washed.

During the morning, Mr. A. was wondering at the city streets, enjoying the morning traffic. Although he did not follow any particular route, the system never ceased transmitting guidance directions. Most of them were concerning regulations of the area traffic and they were coming from traffic police signals, which were selectively received by various vehicles The system decoded one message aimed at him, or rather the area he was going at, and informed him that the road was closed due to road works.

Mr. A. stopped outside a used goods store. Much to his surprise, he was warned that parking was prohibited and the fine was 15,000 currency units, suspension of his driver's license and plates for 3 months, and 2 days of imprisonment. Mr. A. did not stop his car except to a gas station. He travelled towards a bridge at a distance. Just before he approaches the bridge the system warned:

"Mr. A. TURN RIGHT FOR SCHEDULED MEETING".

The system had determined the route towards the first meeting address, at 10.00 a.m., leaving a 15 min margin. Unfortunately, Mr. A. was going to consume all the margin. On the way, he collided with another vehicle while trying to avoid a bicycle. The police arrived after 5 mins, Mr. A. delivered them the protected recording unit so that the police could compare the recorded data from his car and the other vehicle's and could reach a decision in a few hours.

After the event, Mr. A. continued on his course towards his meeting location under the continuous warnings of the system, regarding:

- wheel alignment check
- looseness of wheels check
- tire pressure check for the left front wheel
- balancing check
- shock absorbers check

It seems that the damage was relatively major.

After completing his business meeting Mr. A. headed towards the police station for settling the collision matter. Much to his surprise, the local District Attorney had convicted him to pay the sum of 553,000 units, permanent suspension of his driver's license for this country and a re-examination for driver's license permit. Mr. A. had delivered to the police the traffic violations recording unit and the reckless driving statistics, which was meant for him, instead of the protected unit for recording of the last course meters.

APPENDIX (I)

Differential Equations of motion of a self-powered vehicle at an inclined plane and conclusions [Fig. (101)]

Differential Equation of Motion

$$T-\lambda\ m\ g-m\ g\ \sin u-0.5\ C_D\ \rho\ A\ (U+w)^2 = m\ (d^2S/dt^2) \text{ or}$$

$$T = m\ (g\ (\lambda+\sin u)+\ddot{V}/K)+0.5\ C_D\ \rho\ A\ (\dot{V}/K+w)^2 \qquad (1)$$

(For $w<-U$, $C_D=-C'_D(\text{rear})$, $U>0$, $C'_D>0$)

Integral Equations of Motion - Conclusions

$$d(m.U^2/2) = [T-\lambda\ m\ g\ -m\ g\ \sin u-0.5\ C_D\ \rho\ A\ (U+w)^2]\ dS \qquad (2)$$

$$m\ dU = [T-\lambda\ m\ g\ -\ m\ g\ \sin u-0.5\ C_D\ \rho\ A\ (U+w)^2]\ dt \qquad (3)$$

Integration for Braking with $T=-|T|$: Constant

Setting: $F1 = (|T|+\lambda\ m\ g+m\ g\ \sin u)> 0$ to obtain

$U2<U1$ και $F2 = 0.5\ C_D\ \rho\ A \longrightarrow$

$$\left.\begin{aligned} d(mU^2/2) &= -\{F1+F2\ (U+w)^2\}dS \\ m.du &= -\{F1+F2\ (U+w)^2\}dt \end{aligned}\right] \text{ therefore}$$

$$t_{1->2} = \frac{m}{\sqrt{F1\ F2}}\ (\text{ArcTan}(\sqrt{\frac{F2}{F1}}\ U1)-\text{ArcTan}(\sqrt{\frac{F2}{F1}}\ U2),$$

$$\text{If} \quad U1=U,\ U2=0 \longrightarrow t = \frac{m}{\sqrt{F1\ F2}}\ \text{ArcTan}(\sqrt{\frac{F2}{F1}}\ U) \qquad (4)$$

where $U1=\dot{V}1/K$ $\quad U1=\dot{V}2/K$ $\quad U=\dot{V}/K$

$$S_{1\to2} = \frac{m}{2}\left[\frac{1}{F2}\ln\left|\frac{F1+F2(U+w)}{F1+F2(U2+w)}\right| - \frac{w}{\sqrt{F1-F2}}\left[\mathrm{ArcTan}\left(\sqrt{\frac{F2}{F1}}\,U1\right) - \mathrm{ArcTan}\left(\sqrt{\frac{F2}{F1}}\,U2\right)\right]\right]$$

If

$$U1=U \qquad U2=0 \qquad w=0 \longrightarrow S = \frac{m}{2\ F2}\ln\left[1+\frac{F2\ U}{F1}\right] \tag{5}$$

$$U1=\dot{V}1/K \qquad U1=\dot{V}2/K \qquad U=\dot{V}/K$$

APPENDIX II

VEHICLE TURNING: (Reaction forces caused by the Centrifugal force and the Moment of Inertia of the vehicle). From the geometry of Fig. (131) the reaction forces and the Centrifugal force due to rotation of the mass center about O, are determined.

$$R_1 = \frac{X_1}{\cos\alpha} = F_c \frac{\sin\gamma}{\tan\psi\ \cos\alpha}\ \frac{\tan\psi-\tan\theta}{\tan\alpha-\tan\theta}$$

$$R_2 = \frac{X_2}{\cos\theta} = F_c \frac{\sin\gamma}{\tan\psi\ \cos\theta}\ \frac{\tan\alpha-\tan\psi}{\tan\alpha-\tan\theta}$$

$$R_p = m\ \omega_0{}^2 \frac{a}{\tan\psi} = \frac{F_c}{r_2}\ \frac{a}{\tan\psi}\ , \qquad F_c = m\ \omega_0{}^2 \frac{b}{\sin\gamma}$$

Due to rotation of vehicle about the center of mass G [Fig. (132)], additional reaction forces R_1', R_2', R_p' are applied to the wheels.

$$I = -\frac{C}{r_0} = \frac{J}{r_0}\ \frac{d\Omega}{dt}\ , \qquad R_1' = I \frac{\cos\gamma}{\tan\psi\ \cos\alpha}\ \frac{\tan\psi-\tan\theta}{\tan\alpha-\tan\theta}$$

$$R_2' = I \frac{\cos\gamma}{\tan\psi\ \cos\theta}\ \frac{\tan\alpha-\tan\psi}{\tan\alpha-\tan\theta}\ , \qquad R_p' = I \frac{\cos(\psi-\gamma)}{\sin\psi}$$

The total angular velocity $\Omega = \omega_0 - \omega_1$, where

$$\omega_0 = \frac{U}{r_0} = \frac{U\tan\theta}{M} \sqrt{1+(b/m)^2\tan^2\theta} \approx \frac{U\tan\theta}{M}$$

$$\omega_1 = \frac{d\gamma}{dt} = \frac{b}{M}\,\frac{\theta'}{\cos^2\theta+(b/M)^2\,\sin^2\theta} \quad \text{,hence}$$

$$\frac{d\Omega}{dt} = \frac{dU}{dt}\,\frac{\tan\theta}{M} + \frac{U}{M}\,\frac{\theta'}{\cos^2\theta} - \frac{b}{M}\,\frac{\theta''}{\cos^2\theta+(b/M)^2\,\sin^2\theta} - \frac{b}{M}(\theta')^2\,\frac{2\,\sin\theta\,\cos\theta[1-(b/M)^2]}{[\cos^2\theta+(b/M)^2\,\sin^2\theta]} \qquad (1)$$

CONCLUSIONS:

The turn is separated in three parts:

(a) Start of turn, hence θ increases, hence $\theta'>0$. Upon examination of the behavior of each term in equation (1) it can be concluded that: UPON ENTERING A TURN, A LITTLE BRAKING ASSISTS THE VEHICLE FOR BETTER CONTROL ON THE ROAD (MAINLY THE FRONT WHEELS WHICH ARE STRESSED MORE).

(b) During a turn, θ is constant, hence $\theta'= \theta''= 0$, hence:

$$\frac{d\Omega}{dt} = \frac{dU}{dt}\,\frac{\tan\theta}{M}$$

THEREFORE, IF DURING A TURN THE VEHICLE ACCELERATES, IT EXPERIENCES OVERSTEERING, WHILE IF IT DECELERATES, IT EXPERIENCES UNDERSTEERING.

(c) Exit of a turn, hence θ decreases, hence $\theta'<0$, hence: IF WHEN EXITING A TURN THE VEHICLE ACCELERATES, IT EXPERIENCES UNDERSTEERING, THEREFORE THE REAR WHEELS (WHICH ARE STRESSED MORE) ARE ASSISTED IN THEIR BETTER CONTROL ON THE ROAD.

H. CLAIMS

1. A method of routing (that is setting-up the vehicle's course towards a predetermined destination), navigation (that is estimating and verifying the vehicle's position, on the road network at any instant and guiding the driver on the course and manoeuvres he/she has to follow), protection (that is checking the vehicle's condition and driver's physical status, controlling the driving conditions and the proper performance of manoeuvring and warning or interfering in case of emergency) and guidance (that is supplying information of any kind which fall into the driver's interest during driving), which method is characterised by the provision of a number of services to the driver in order to accommodate his/her needs during vehicle's movement (routing, navigation, protection and guidance services) using a limited number of devices and only by processing their indications, which devices are installed:

1. On-board the vehicle (measurement and protection devices)
2. On the driver (information devices)
3. On the surrounding area (guidance devices)

and which devices are connected with and controlled by a data processing system which is installed on-board the vehicle, in such a way that the processing system, upon receipt of the devices' indications, based on pre-programmed criteria as well as on data stored in its memory unit, to

* identify the road network and the prevailing conditions in every spot (traffic signs, locations and buildings on both sides, topography etc.)
* estimate and verify the vehicle's position on the road network, at any instant
* identify the vehicle's condition and driver's physical status
* identify driver's immediate and future needs on protection and guidance

and based on these elements, it provides the driver with a number of services concerning the routing, navigation, protection and guidance requirements.

2. Method as in claim 1, where the following data are taken into account when determining a route between an origin and a destination, in accordance with the driver's requirements:

* Geometrically shortest route
* Timewise shortest route
* Economy route
* Easiest route

3. Method as in claim 1, where for determining a route, experience, physical condition, and the particular driving features of each driver are considered, where said characteristics are automatically identified and registered in the memory unit.

4. Method as in claim 1, where for determining a route, the type and the particular features of each vehicle are considered.

5. Method as in claim 1, where for determining a route, certain areas or buildings placed on both sides of the road network, which the driver wishes to encounter, are considered.

6. Method as in claim 1, where for determining a route, time or local constraints applied by the driver are considered, and where said route is modified automatically (without the driver's interference) in order to satisfy the said constraints.

7. Method as in claim 1, where the following information concerning the selected route are provided from the start:

* Duration

* Total length
* Average, minimum and maximum speed
* Presentation of said route on section of road map
* Number of required turns
* Traffic signs.
* Any other element of the driver's choice, which may interest him/her.

8. Method as in claim 1, where a route is automatically (without the driver's interference) selected or a previously selected route is modified, depending on the traffic situation of a given road network, where said data concerning traffic are received by the on-board receiver and are automatically (without the driver's interference) processed by the vehicle's data processing unit.

9. Method as in claim 1, where a new route is selected without the driver's interference or a previously selected route is modified, when the vehicle deviates, purposely or not, by the selected route, where the deviation location is the new origin.

10. Method as in claim 1, where a route is determined, towards a multitude of consecutive destinations (one after the other), with or without time constraints.

11. Method as in claim 1, where at the driver's request, the route and the destination are determined (when the destination belongs to a group of similar destinations, such as drugstores, gas stations), in such a way that the said route is the shortest, timewise, towards one of the said destinations.

12. Method as in claim 1, where a destination and the time of arrival are selected, and the vehicle's course is continuously monitored. At the proper time instant a route is determined, from the current location towards the said destination, which guarantees timely arrival. Furthermore,

when the driver deviates from the predetermined route, he/she is immediately warned if the said deviation will cause significant deviation and will not allow for timely arrival.

13. Method as in claim 1, where a route is determined, towards locations which do not consist part of the road network (such as parking areas, docks, jungles), where the said route is determined without any driver's interference, solely by obstacle avoidance or area topography monitoring criteria.

14. Method as in claim 1, where the determination of a route includes additional information such as:

* cost
* characteristics such as in claims 1, 6, 7, 10, 12

for satisfying the requirements of certain professionals (taxi drivers, truck drivers, courier services etc.).

15. Method as in claim 1, where for a route determination, certain road network peculiarities are considered, such as:

* channels existence
* ferries existence or use
* check points existence or use

for better conformity of the vehicle's motion, to time constraints imposed by said peculiarities, according to claim 6.

16. Method as in claim 1, where a route determination and its automatic (without the driver's interference) modification, depend on weather conditions (such as wind, ice, rain) which are observed along the road network, road network topography peculiarities (such as declivities, hazardous slopes) which are either automatically identified by the system or received by the on-board receiver from an external transmission source.

17. Method as in claim 1, where the parameters and factors affecting the initial determination of a route or an already determined route, are automatically identified by the system, without any driver's interference.

18. Method as in claim 1, where the route determination or modification procedure is activated by the continuous monitoring of factors, parameters and conditions during driving.

19. Method as in claim 1, where for a route determination towards a predetermined destination, the following hardware is required:

* Processing unit on board the vehicle
* Peripherals such as, memory unit, I/O unit
* Chronometer
* Receiver

MEMORY UNIT DATA

20. Memory unit as in claim 19, where the road network is registered in the form of a lattice, i.e. in the form of a network of nodes connected via straight segments. The said representation is only topological, and no reference to the geographic coordinates of the said nodes is made.

21. Memory unit as in claim 19, where the road network topology, as per claim 20, is classified in levels, depending on the greater area which contains any section of the road network (i.e. road network level which interconnects nations belonging to the same continent, road network level which interconnects cities belonging to the same nation, etc.).

22. Memory unit as in claim 19, which includes auxiliary road network data such as:

* Transversal and longitudinal road surface slope at every few travelled meters
* Road surface quality
* Available traffic lanes
* Intersections' geometry
* Permanent traffic signs
* Traffic lights' location and programming
* Length of road sections between two provinces
* Zip code of road section between two nodes
* Building numbering on both sides of the road
* One-way roads
* Seasonal, time-varying or local changes of road network conditions
* Assignment, to each of the road segments, of a scale number which, with all the above considered, represents the difficulty of vehicle's passing and the time delay.

23. Memory unit as in claim 19, where the following are registered:

* General interest information concerning areas or buildings on both sides of the road.
* Elements of the road network and surrounding areas, which vary during one day, week, month or year.

24. Memory unit as in claim 19, where the topology and geometry of complicated intersections, such as multi-leveled nodes, are registered.

25. Method as in claim 1, where claims 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 are embodied, by consideration by the on-board data processing system of the memory unit data, as they are described by claims 20, 21, 22, 23, 24, i.e. driver requirements, vehicle type, receiver data, odometer indication, and results of checking of vehicle and driver.

<u>POSITION ESTIMATION</u>

26. Method as in claim 1, where the driver verifies passage

by distinctive locations of the road network (such as nodes, bridges, traffic lights), by pressing of a special key at the time of passage by said locations.

27. Method as in claim 1, where the vehicle's position is verified by the reception of a transmitter signal, where said signal does not contain any message, but can be interpreted to vehicle's location information, depending on the vehicle's location or motion.

28. Transmitter signal reception as in claim 27, where the vehicle's direction of motion is verified by the indication of an on-board compass, whereas the said indication is a data continuously supplied to the data processing unit.

29. Vehicle's position verification by reception of a transmitter's signal as in claim 27, where the exact vehicle's location is determined by the calculation of one half of the travelled distance, during reception of the transmitter's signal.

30. Method as in claim 1, where the vehicle's position is verified by comparison of vehicle's manoeuvring (e.g. turns) with road network data, which are registered in the memory unit (e.g. road curvature), as per claim 22.

31. Method as in claim 1, where vehicle's location errors originating from:
* The distance measuring system
* The memory unit data registration

are automatically (without driver's interference) corrected, by use of correction factors, which depend on errors repetition and statistics.

32. Method of vehicle's position error correction, as in claim 27, which allows for the registration of the road network data on a scale, and the automatic determination of the proper correction and measurement factor.

33. Method as in claim 1, where the vehicle's position estimation on the road network, along with the majority of the driver's guidance and protection services, and the driver's, surrounding environment's and vehicle's condition control services, are realised by the use of odometers and wheel's transversal angle measuring device only.

34. Method as in claim 1, where the vehicle's position estimation on the road network is realised by transmission of acoustic (or other) signal, transversely to the vehicle's direction of motion, and consequent reception of the reflected to buildings and obstacles signal.

35. Method as in claim 1, where the road network is registered in the memory unit according to the indications of the reception of the reflected acoustic signal, at each travelled meter, as per claim 34.

36. Method as in claim 1, where the vehicle's position estimation on the road network is verified by the driver, through transmission of optical (or other) signal, from distinctive road network locations (such as nodes, gas stations).

37. Method as in claim 1, where the combination of indications by the odometer and the wheel's transversal angle sensor, allow for the vehicle's position estimation on areas which are not part of the road network and which do not include roads (such as parkings, docks, unmapped areas).

38. Method as in claim 1, where the vehicle's position estimation on any multi-story building level is realised by reception of a transmitter's signal, which is different for each level.

39. Method as in claim 1, where the vehicle's position estimation verification on a multi-story building level is realised by monitoring of manoeuvres for travelling from one

level to another (e.g. monitoring of circular turns of radius equal to the upwinding or downwinding spiral ramp's radius).

40. Method as in claim 1, where the vehicle's position estimation verification methods, as per claims 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, overlap and are compared to each other for maximum reliability on vehicle's position and direction estimation.

41. Method as in claim 1, where the vehicle's position estimation, is realised by the use of transmitters, installed along the road network, where each transmitter transmits simultaneously two signals; an electromagnetic wave and an acoustic (e.g. ultrasonic), in such a way that by the time lag between said two signals, the distance from the transmitter is determined.

GUIDANCE

42. Method as in claim 1, where directions for driver's guidance are supplied acoustically by voice (e.g. TURN RIGHT), and acoustically by continuous or repeated single sound or musical tone.

43. Method as in claim 1, where directions for driver's guidance are supplied on a display, either by alphanumeric characters or figures or pictures.

44. Method as in claim 1, where directions for driver's guidance are supplied via device which is in contact with the driver's skin. The said directions are provided either through moving guides, which irritate the skin linearly, or through sequential activation of pins for skin irritation at points, where the sequence of said irritations forms the direction characters or signals.

45. Touch device as in claim 44, where said device is

wirelessly connected to the rest of the method's devices.

46. Method as in claim 1, where the guidance, control, protection and information directions are provided by a combination of all three methods, i.e. acoustically as per claim 42, visually as per claim 43, and by the touch device as per claims 44 and 45.

47. Supply of directions by acoustic signal as per claim 42, where a BEEPER sound is transmitted for position verification, upon passing by distinctive road network locations (e.g. nodes), a sequence of acoustic signals of increasing pitch or frequency is transmitted, upon approaching a node or a manoeuvre location, and musical tones or distinctive sounds are transmitted for transmission of information and other directions.

48. Method as in claim 1, where encoded words, visual signals, messages and figures are transmitted by the sense of touching for the description of complicated intersections (multi-levelled nodes), where said words, signals, messages and figures represent the intersection geometry and the course to be followed by the driver. The said geometry and said messages to the driver are different for different entries to the intersection and they coincide with the driver's visual impression at the node entry point.

49. Method as in claim 1, where 2 groups of blinkers, located to the left and to the right of the driver's view field are used for visual supply of guidance and control directions. The sequential or simultaneous activation of said blinkers guides the driver for oncoming manoeuvres or controls for hazardous situations.

50. Method as in claim 1, where an indicator and a frame denote the vehicle's position and the surrounding area, where safe driving is ascertained when the indicator is maintained inside the frame boundaries, in cases of no

visual contact with the environment.

51. Method as in claim 1, where the driver is informed about the current traffic lane, any lane change and the lane he/she should move to, by the methods of claims 42, 43, 44.

52. Method as in claim 1, where for supply of directions to the driver, regarding direction, manoeuvre, control, protection and information, the on-board processing system considers the instantaneous vehicle location on the road network, as per claims 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, the determined route as per claims 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, the memory unit data as per claims 20, 21, 22, 23, 24, and the vehicle's motion as it is provided by the indications of the odometers and the directional wheel's angle measuring device.

53. Guidance as in claim 52, where the supplied to the driver directions are considering not only the driver's immediate needs, which arise from the oncoming road network data, but also any future actions which the driver should be prepared for (such as frequent intersections, short blocks, consequent traffic signs).

54. Method as in claim 1, where exact directions are provided to the driver, as per claims 42, 43, 44, for the execution of manoeuvres in special or bounded areas (such as manoeuvres for parking between two vehicles), by entering by the driver of the area boundaries into the memory unit, where the vehicle is used for data collection. Consequently, the data processing system determines the proper course and then provides guidance concerning the said course, in the form of specific manoeuvres which must be followed.

55. Method as in claim 1, where special directions are foreseen for special driver categories and special driver

needs (such as trainees, elderly, people with special needs), by entering of driving specifications (such as maximum speed, maximum engine rpm (as in new vehicles), which are taken into account in conjunction with the data for supply of directions, as per claim 52.

56. Method as in claim 1, where the driver is warned (visually, acoustically and by the touch) about the proper pressure on the accelerator pedal for the maximum allowable speed at the current location, in such a way, that the directions concerning said pressing are provided in relation to the current speed, until the reaching of the desired speed limit.

57. Method as in claim 1, where directions are provided concerning manoeuvres at racing fields or cross country, where two independent wheels are employed, which are elastically supported to the vehicle in such a way that they are always in contact with the ground. The rotations combined with the transversal angle of the said wheels provide indications for position, motion and acceleration of the vehicle.

58. Method as in claim 1, where for manoeuvre guidance of any kind, besides the data as per claim 52, the geometry and the dynamics of the vehicle are considered, especially for the case of tractor vehicles or the case of ambulances and fire drills, where certain specifications must be set, concerning speed, type of manoeuvres, etc.

59. Method as in claim 1, where the travelled distance and the directional wheels transversal angle measuring devices, are used for direct control regarding conformity to guidance instructions, which are provided piece by piece (e.g. TURN - TURN - TURN ... STOP). In case of false manoeuvring, corrective guidance is provided in order for the manoeuvring to be properly executed.

60. Method as in claim 1, where for certain areas that do not constitute part of the mapped road network or they do not have roads (e.g. ports, loading docks, parkings), the directions are provided externally by a special guidance program, which considers the occasional area topography (such as obstacles, boundaries etc.), each vehicle's characteristics and the initial location, which is always defined.

61. Method as in claim 1, where for traffic management and solution of environmental pollution problems at big cities, awareness and guidance of drivers by the traffic management service is foreseen.

62. Driver's awareness and guidance, as per claim 61, via a central transmitter station which transmits messages containing commands, deviation directions, warnings and personal calls, which are escorted by a vehicle ID or a location code number, in order to be decoded by vehicles of certain location or ID.

63. Driver's awareness and guidance, as per claim 61, via substations of the present service, located at key points, which transmit messages upon activation by the central station.

64. Driver's awareness and guidance, as per claim 61, via portable transmitters which transmit messages containing commands, directions and warnings, which are placed at key road locations and they can be removed or relocated.

65. Driver's awareness and guidance, as per claim 61, via portable, short-range transmitters which are operated by the service employees, where their transmitted messages concern the nearby moving vehicles.

66. Driver's awareness and guidance, as per claim 61, through messages registered in the memory unit, concerning

highest traffic hours of the main roads, special hours for passing through certain areas, demonstration dates, statistical data for road traffic, when the vehicle moves on the particular road at the particular time that the message refers to.

67. Method as in claim 1, where driver's awareness and guidance to avoid traffic congestion, is affected when the average vehicle's speed is lower than the one which is statistically predicted and stored in the memory unit (for the specific road section).

68. Method as in claim 1, where the driver, upon noticing an oncoming traffic congestion, can select a new route, as per claims 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 by the following methods:

* By subtraction of nodes corresponding to the congested area from the originally selected route
* By cancelling of original route and selection of new one
* By deviation by the driver of the congested area, which results to an automatic rerouting
* By selection from the beginning of a route with little statistical possibility of traffic congestion at the time of the vehicle's passing.

PROTECTION

69. Method as in claim 1, where the driver's physical condition is monitored (whether he is dosing, absent-minded, hyperactive) by checking of the minor variations in direction and speed, as they arise by the detailed monitoring of the odometer's and the directional wheels' transversal angle of turn sensor indications, in comparison to good physical condition driving standards.

70. Method as in claim 1, where at the driver's request, directions ensuring the driver's alertness are supplied.

71. Method as in claim 1, where the driver is warned, as per claims 42, 43, 44, for deviations of his/her course of more than 1.5 m (which corresponds to one half of the average lane width), when such a situation arises during monitoring of the direction variations.

72. Method as in claim 1, where the driver is warned for deviations of his/her predetermined course, as it is determined per claims 26 to 40, and the deviation is not justified by topography data (e.g. turn), lane change, or entrance to an unmapped area.

73. Method as in claim 1, where the starting symptoms of aquaplaning are identified by the use of odometer only, i.e. by comparison of indications of two odometers, installed at a driving and a non-driving wheel each, where for the same travelled distance, larger distance is measured by the driving wheel.

74. Method as in claim 1, where strong winds, transversal to the vehicle's direction of motion, are detected by existence of abrupt change and recovery of the indications of the directional wheel's angle of turn measuring device.

75. Method as in claim 1, where the slipperiness of the road surface is detected by comparison of the indications of the driving wheels' odometers, where said indications are escorted by abrupt changes of the indications of the directional wheels' transversal angle sensor, towards one direction.

76. Method as in claim 1, where the slipperiness of the road surface is detected by consecutive abrupt changes of the indications of driving wheels' odometers.

77. Method as in claim 1, where the alternations of the vehicle odometers' indications during the speed's variations, due to normal variations of the pressing of the

accelerator pedal by the driver, are examined in detail, particularly before, during and after the said pressure application and release on the pedal, where the minor indication alternations are compared to (typical) standard alternations for detection of:

* Strong front wind
* Strong rear wind
* Overloaded vehicle
* Engine power loss due to lack of coolant or lubricant
* Engine power loss due to electrical circuits' malfunction
* Road surface slope
* Brakes' wear.

78. Method as in claim 1, where the driver is warned about driving safely and notified about the proper speed ahead of traffic signs and traffic lights, where the vehicle speed, the road surface quality, the weather conditions, the state of the vehicle (e.g. brakes) and the driver, are always taken under consideration, which are detected as per claims 69 through 77.

79. Method as in claim 1, where the driver is guided for proper speed when executing a turn, where the vehicle's dynamics for motion along a curve, the speed checks depending on the topographic modulation of the turn and the checks as per claims 69 through 77, are taken into consideration.

80. Method as in claim 1, where the wheel balancing is checked, by the existence, at certain speed, of periodic, intense, abrupt indication changes (mainly the odometer's and the directional wheel's transversal angle measuring device's), in conjunction with the speed where the said changes appear.

81. Method as in claim 1, where the condition of the vehicle's suspension is checked, by examination of the odometer's and the directional wheel's transversal angle

measuring device's indications, for local, periodic, abrupt changes' existence.

82. Method as in claim 1, where the proper alignment of the vehicle's directional wheels is checked, by examination of the directional wheel's transversal angle measuring device's indications integration over a long period of time, and examination of the deviation from the zero value.

83. Method as in claim 1, where the the proper alignment of the directional wheels is checked, by examination of the abrupt changes of the required minor course corrections, as they are depicted by the directional wheel's transversal angle measuring device's indications.

84. Method as in claim 1, where the looseness of the directional system and the wheels' supports are checked, by examination of the odometer's and the directional wheel's transversal angle measuring device's indications, for detection of abrupt, knocking type and origin changes.

85. Method as in claim 1, where the tire wear is checked, by examination of the odometer's indications during braking.

86. Method as in claim 1, where the tire wear is checked, by examination of the odometer's indications deviations, where said deviations are slowly increasing as time progresses.

87. Method as in claim 1, where the tire pressure is checked, by examination of the odometer's indications deviations, where said deviations are rapidly increasing as time progresses.

88. Method as in claim 1, where the excessive vehicle weight is checked, by examination of the odometer's indications deviation from the start, where said initial deviation remains constant as time progresses.

89. Method as in claim 1, where for the cases mentioned in claims 69 through 88, in case of hazard the following are foreseen:

* Simple driver's warning by the methods of claims 42, 43, 44, by a characteristic signal of increasing frequency proportional to the hazard level or the remaining distance.
* Nearby driver's warning by transmission of a characteristic, encoded, hazard signal from the vehicle's transmitter.
* Guidance to the driver, in order to avoid the danger.

90. Nearby driver's warning as in claim 89, where the transmitted signal includes information about position, direction, and vehicle identification for identification by other drivers.

91. Method as in claim 1, where the driver is warned for proper use of head lights and speed, during passing through tunnels, and compliance checking through sensors in the electric system and the indication of the odometer.

92. Method as in claim 1, where the driver is warned for reverse vehicle movement, as it is detected by a special wheel rotation's sensor, or a special arrangement of odometers for forward movement measurement, for detection of backward movement as well.

93. Method as in claim 1, where the driver is warned when he/she uses the direction lights, indicating intention for a turn where the topographic data prohibit it (one-way).

94. Method as in claim 1, where the driver is warned about restrictions or complete prohibition for passing from certain locations of the road network as they are recorded in the memory unit. Furthermore, the penalty in case of violations of the restrictions is also announced.

95. Method as in claim 1, where certain locations of the

road network where increased accidents frequency is detected, are registered in the memory unit, and where the driver is notified about said locations by the methods of claims 42, 43 44 ahead of the said locations.

96. Method as in claim 1, where any vehicle collision is detected by :

* the indication of an on-board accelerometer,
* an abrupt change or decrease in the indications of the odometers and the directional wheels angle measuring device.

97. Method as in claim 1, where manual or automatic immobilisation of the vehicle is foreseen, in case of inability to avoid a direct hazard, by launching and thrusting of a spike into the road surface, where said spike holds and decelerates the vehicle through a thread.

98. Method as in claim 1, where a memory unit strongly protected against mechanical, thermal, chemical stresses and other field type effects, is foreseen, where data concerning the last interval of the vehicle's motion are recorded, where said data are sufficient for simulating the driving conditions during said last interval when requested (e.g. in case of collision). Sufficient data for said simulation are the indications of the odometer's, the last indications of the directional wheel's transversal angle measuring device, the departure node, indications of the headlights' sensors and the direction indicator lights).

99. Method as in claim 1, where the vehicle's speed, which is determined by the odometers' indications, is continuously recorded in a special file in the memory unit or in a special memory unit.

100. Method as in claim 1, where periodic transmission of timely and up-to-date information by a central area station is foreseen, where said information concerns open drugstores, vacant hospitals, weather report, strikes, ferry

schedule etc., and said information are escorted by a code number indicating the vehicles which are authorised to receive them via the on-board receiver.

101. Method as in claim 1, where any vehicle's violations of the traffic regulations or the safe driving rules, as they arise by examination of the vehicle's motion data in comparison to the road network data which are registered in the memory unit as per claims 20, 21, 22, 23, 24, are recorded in a special file in the memory unit or in a special memory unit.

102. Method as in claim 1, where individual, statistic, driving characteristics of any driver, and statistic data concerning the hazard level of the particular driving type, are recorded in the memory unit, for identification of the particular driver and adjustment of the supplied directions for driver's guidance and protection.

103. Method as in claim 1, where installation in a protected vehicle point of an autonomous transmitter for protection against theft, is foreseen, where said transmitter is automatically activated upon engine ignition or vehicle movement due to theft, where deactivation of said transmitter is only possible when a characteristic code number (password) is entered to the system.

104. Method as in claim 1, where specific directions regarding handling and protection manoeuvres are supplied as per claims 42, 43, 44, in case of vehicle spinning and total loss of traction of the vehicle's wheels, as determined by a study of the dynamic vehicle behavior during slipping of the wheels' contact points with the ground.

105. Method as in claim 1, which is embodied mainly by an on-board data processing system, memory unit, peripherals, I/O, receiver, transmitter, odometer, wheel's transversal angle of turn measuring device, and ON-OFF indicator sensors

installed at the vehicle's electrical system.

INFORMATION

106. Method as in claim 1, where before passing under or over bridges, certain information regarding height and width for passing under, and maximum weight and width for passing over bridges, is provided to the driver as per claims 42, 43, 44.

107. Method as in claim 1, where the driver registers in the system's memory unit the meeting schedule for a specific time period (daily, weekly, monthly plan etc.), and at the appropriate time instant, the system notifies the driver about said meetings and performs routing for timely arrival to each destination.

108. Method as in claim 1, where particular destinations (e.g. addresses, names, buildings of a certain operation) are registered in the system's memory unit, where said destinations are recalled from memory, by simple keying on a keyboard or tracing on the touch device, of a number, which corresponds to the sequence number of the specific destination classification in the memory unit.

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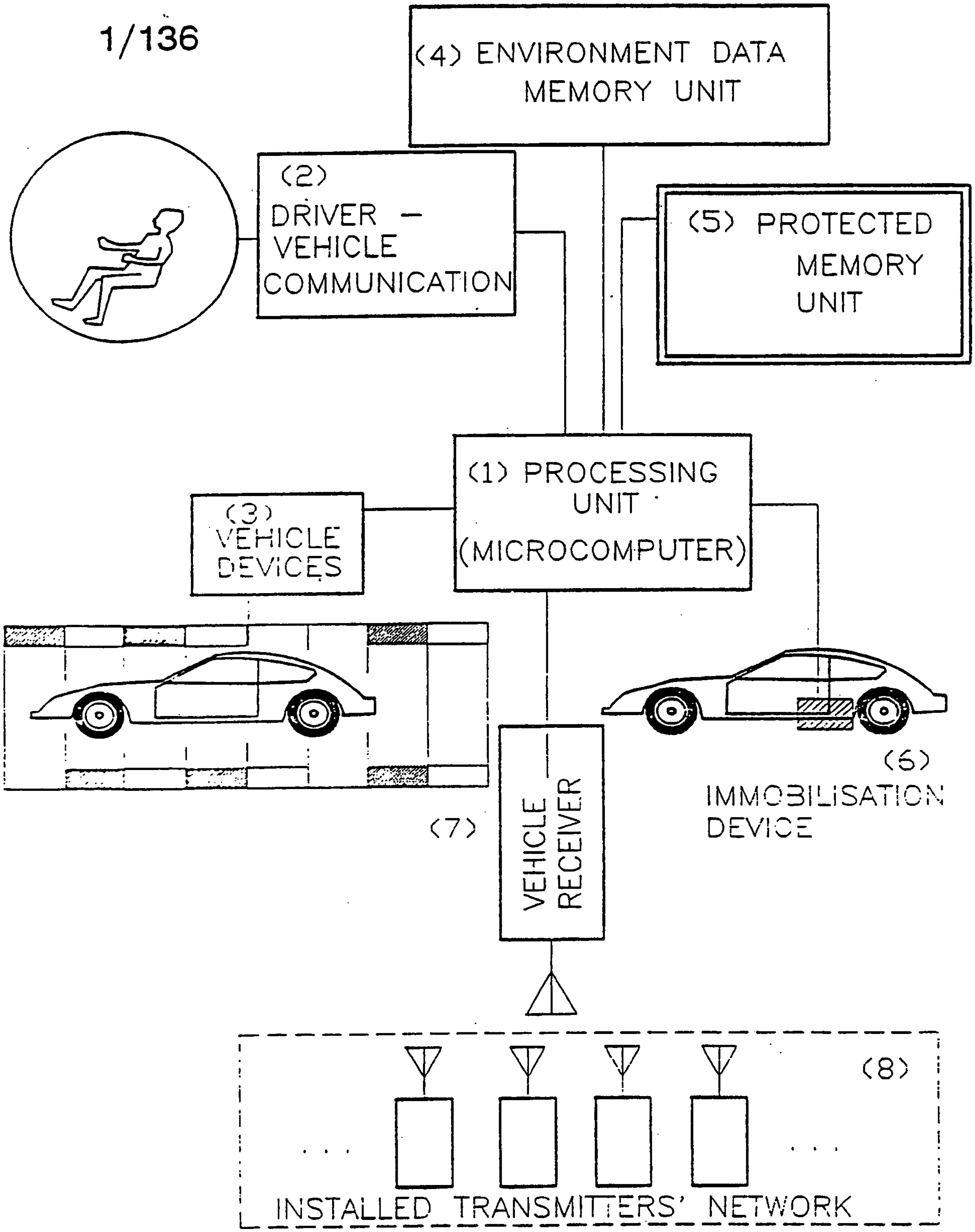

FIGURE 1

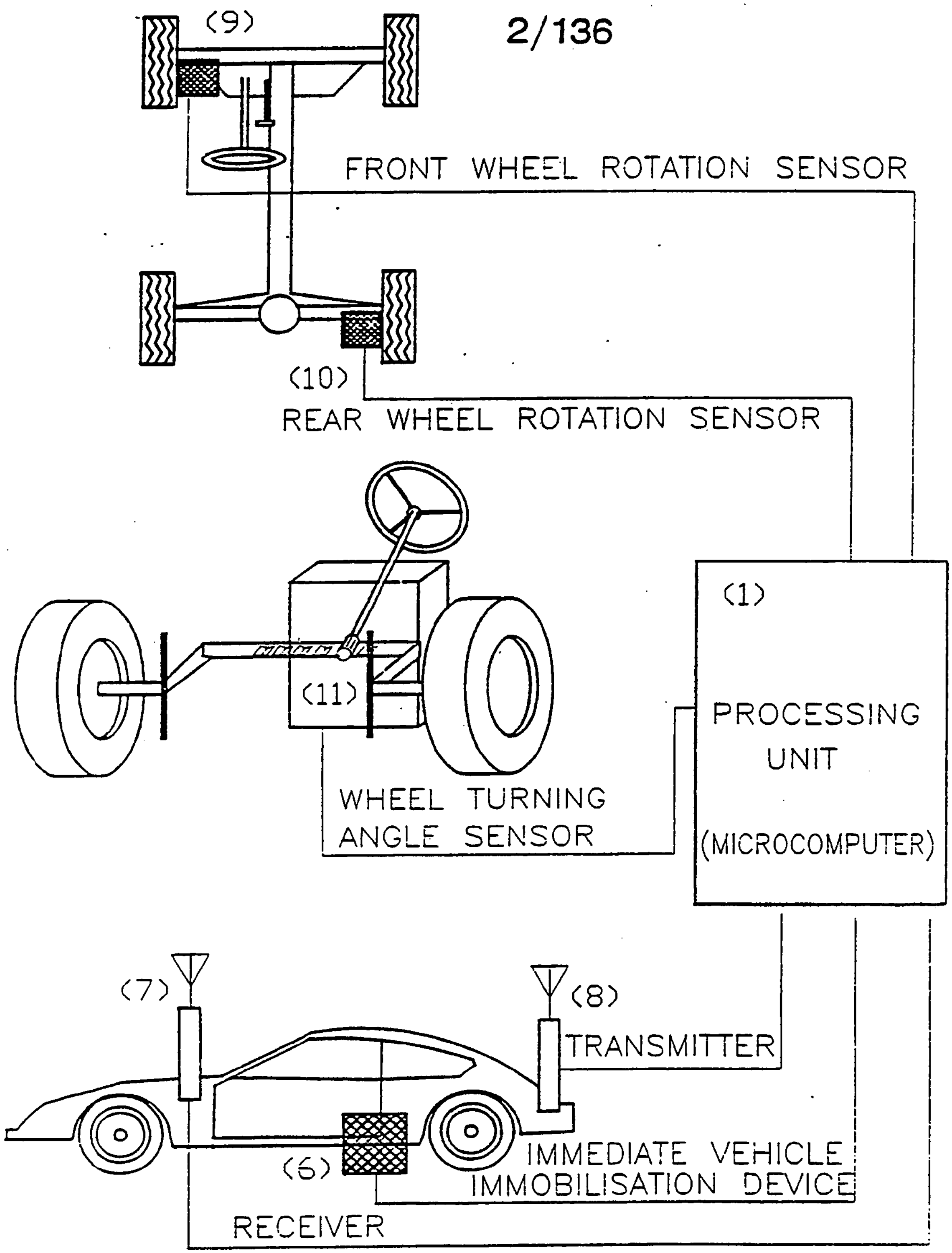
(9)
FRONT WHEEL ROTATION SENSOR
(10)
REAR WHEEL ROTATION SENSOR
(11)
WHEEL TURNING ANGLE SENSOR
(1)
PROCESSING UNIT
(MICROCOMPUTER)
(7)
(8)
TRANSMITTER
IMMEDIATE VEHICLE IMMOBILISATION DEVICE
(6)
RECEIVER

FIGURE 2

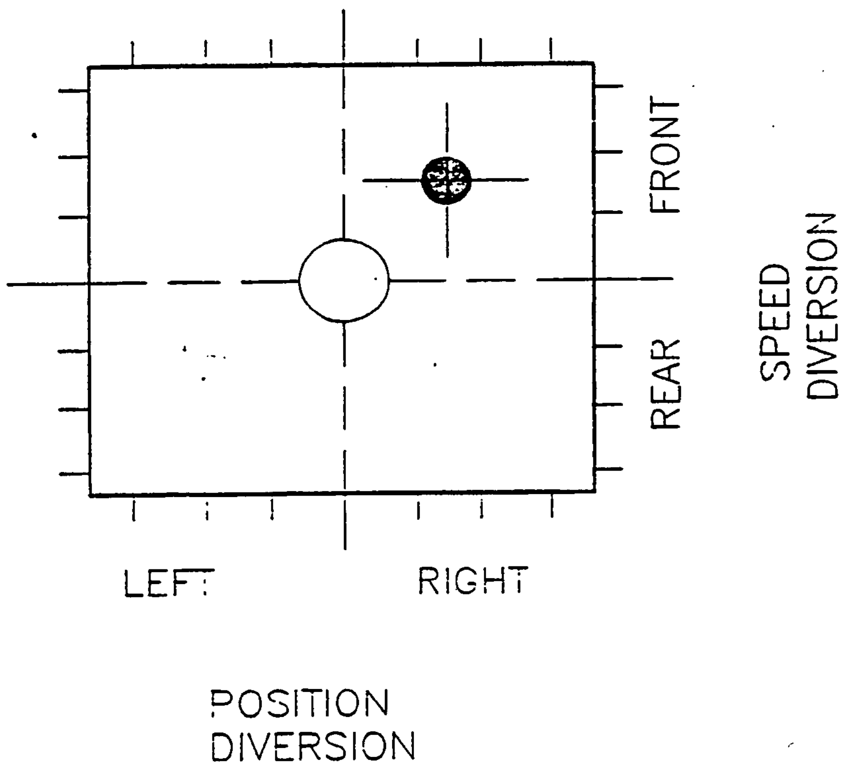

FIGURE 3

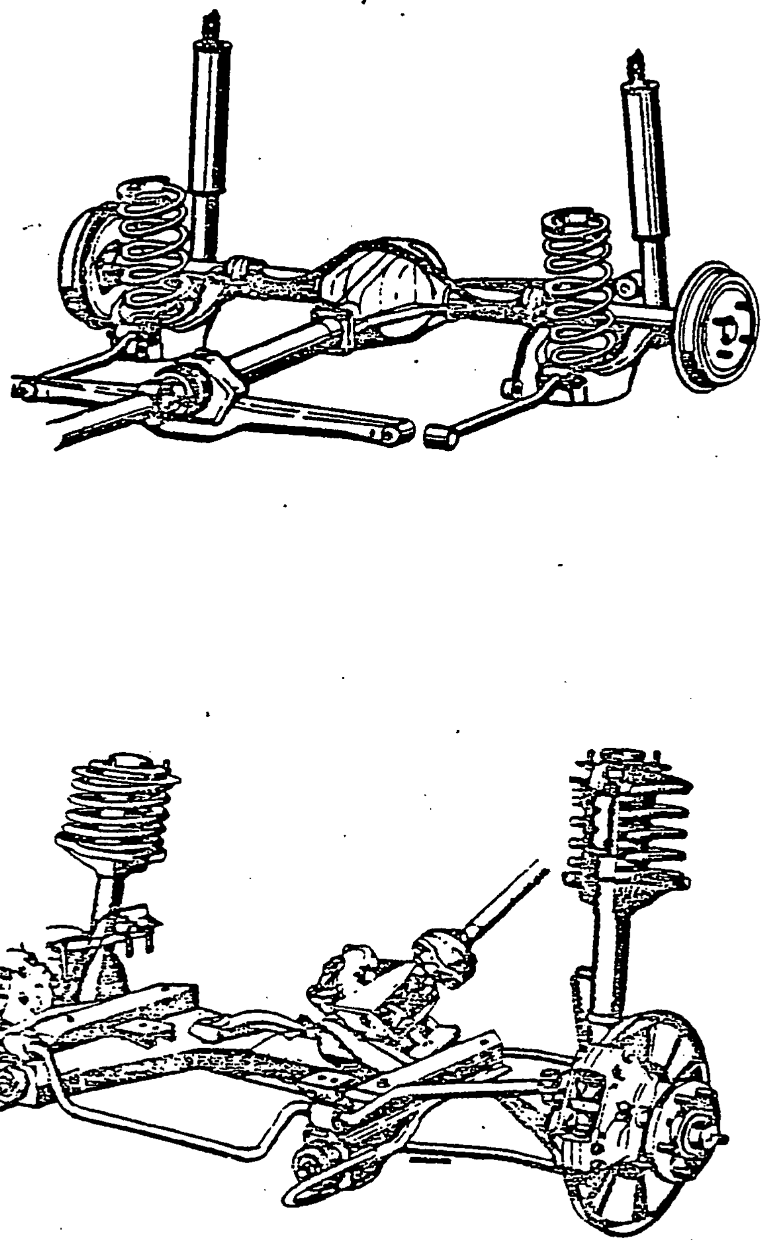

FIGURE 4

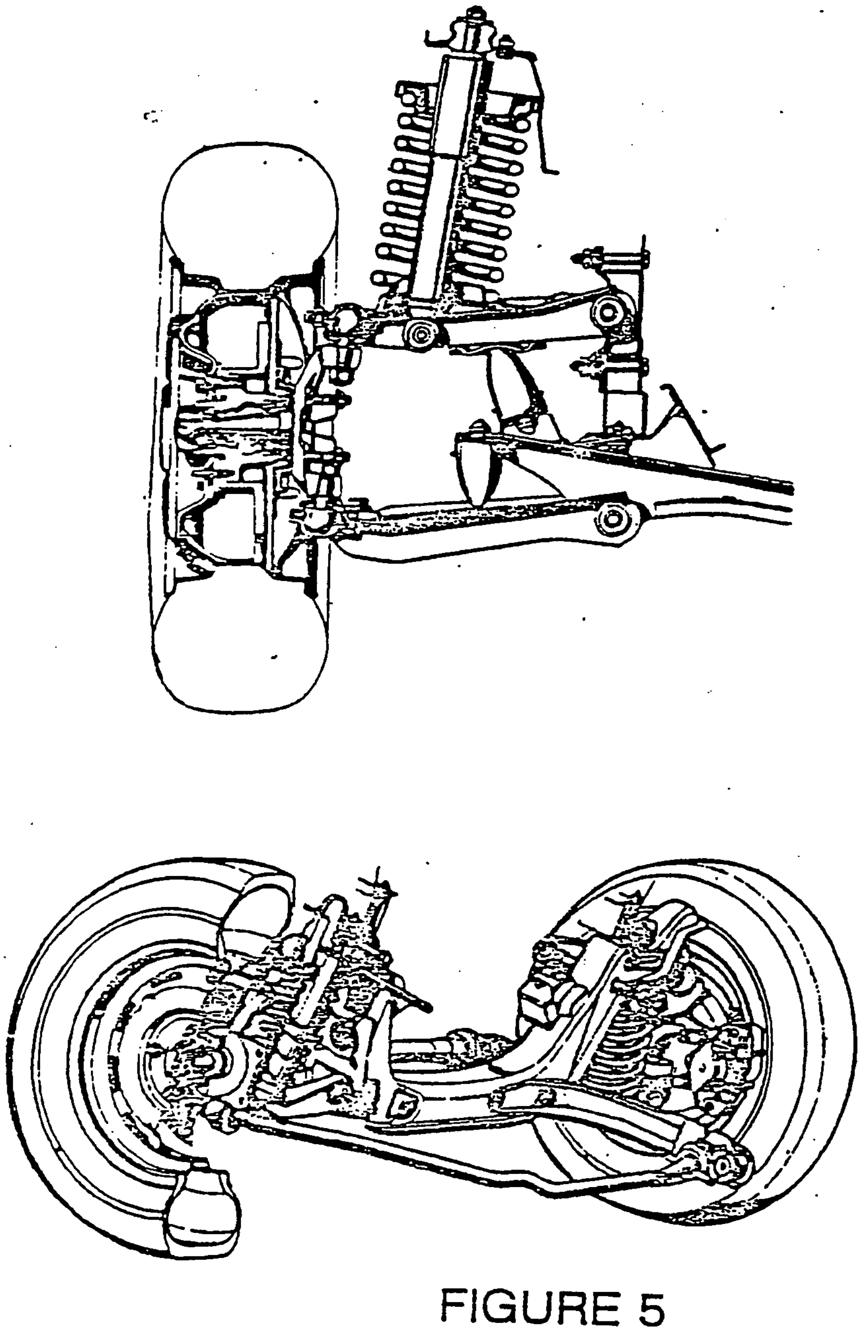

FIGURE 5

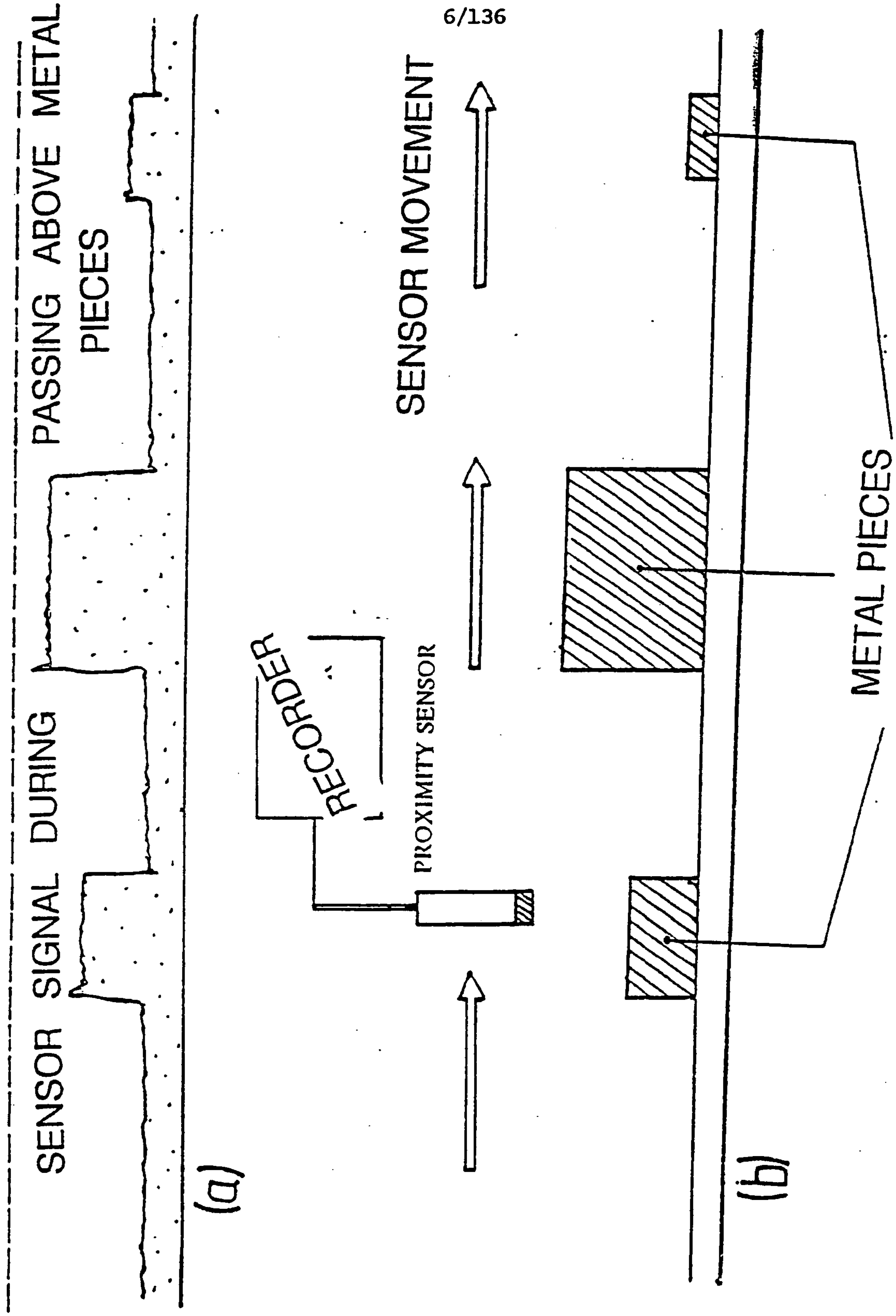

FIGURE 6

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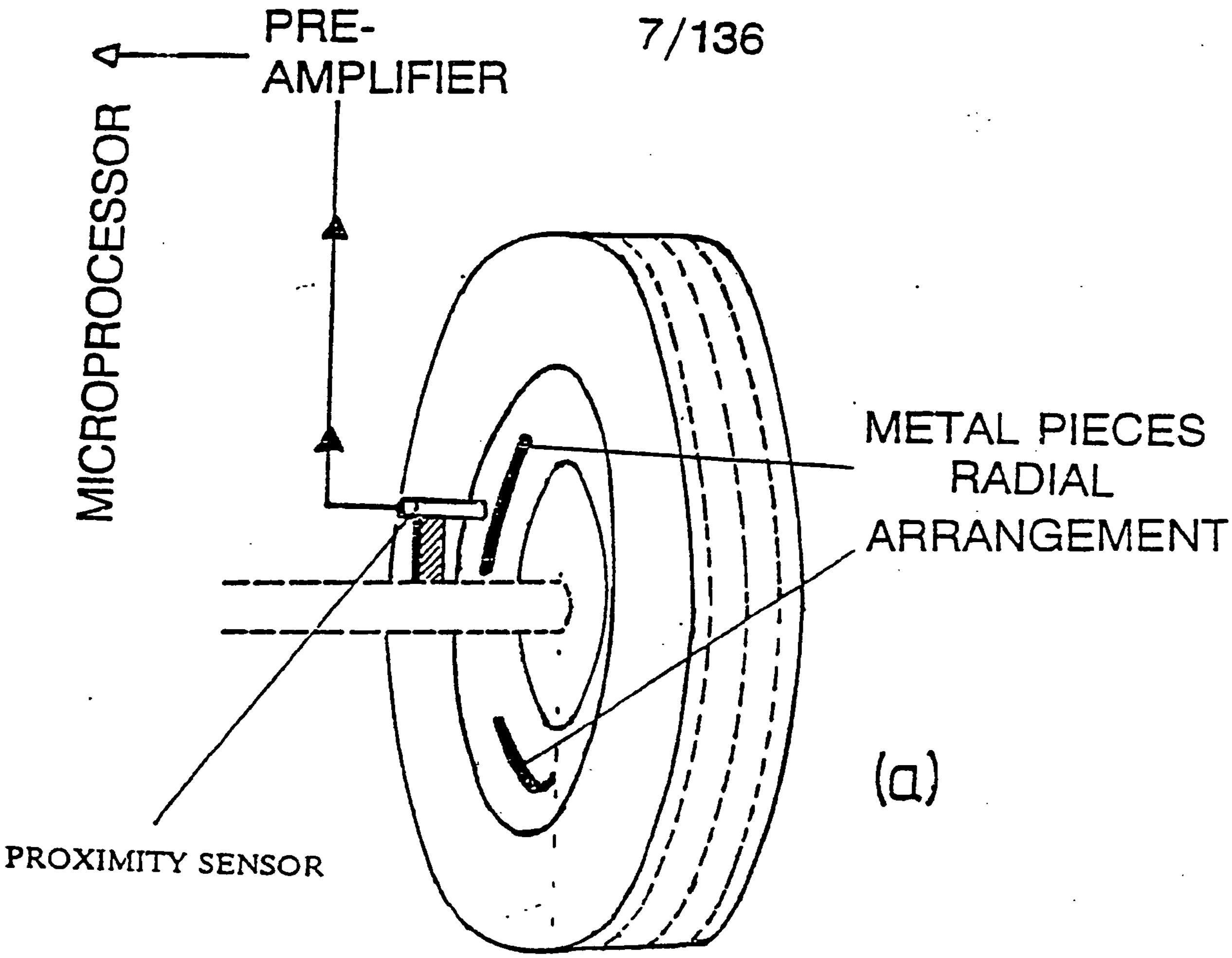
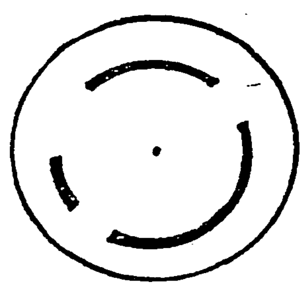


(a)



(b)

UNEVEN METAL PIECES ARRANGEMENT ON THE WHEEL

FIGURE 7

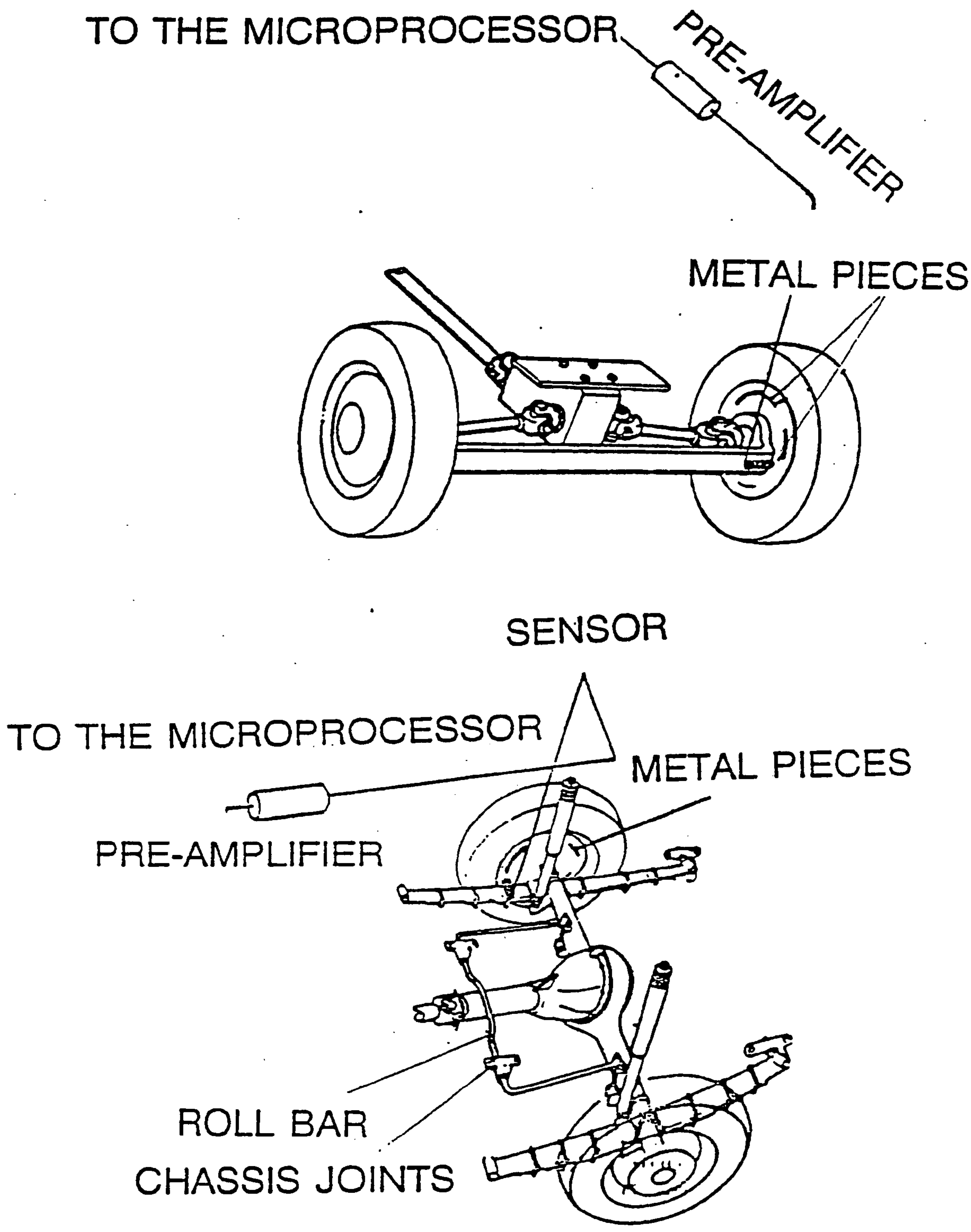

TO THE MICROPROCESSOR
PRE-AMPLIFIER
METAL PIECES
SENSOR
TO THE MICROPROCESSOR
METAL PIECES
PRE-AMPLIFIER
ROLL BAR
CHASSIS JOINTS

FIGURE 8

DIFFERENTIAL COMPONENTS

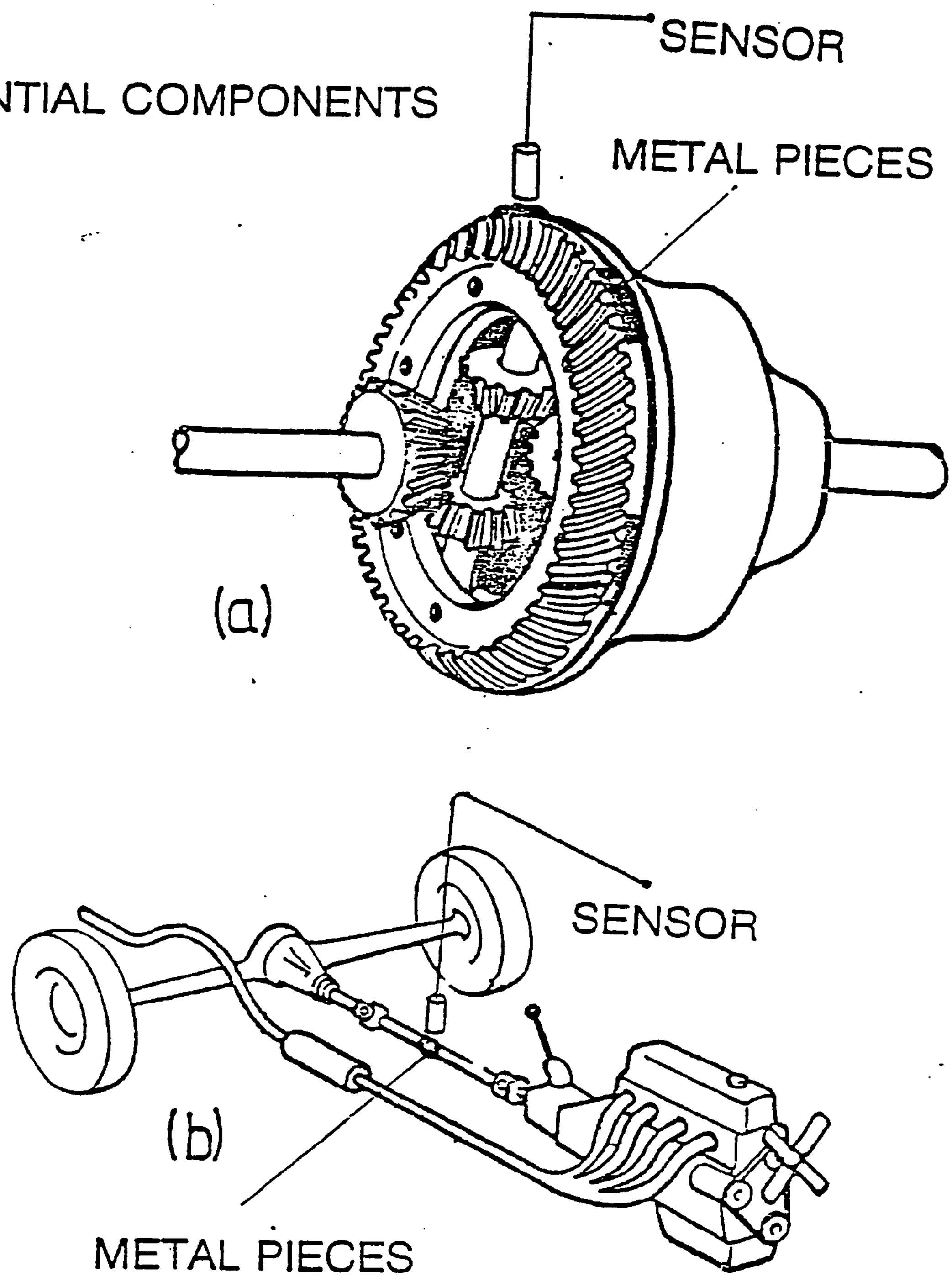


FIGURE 9

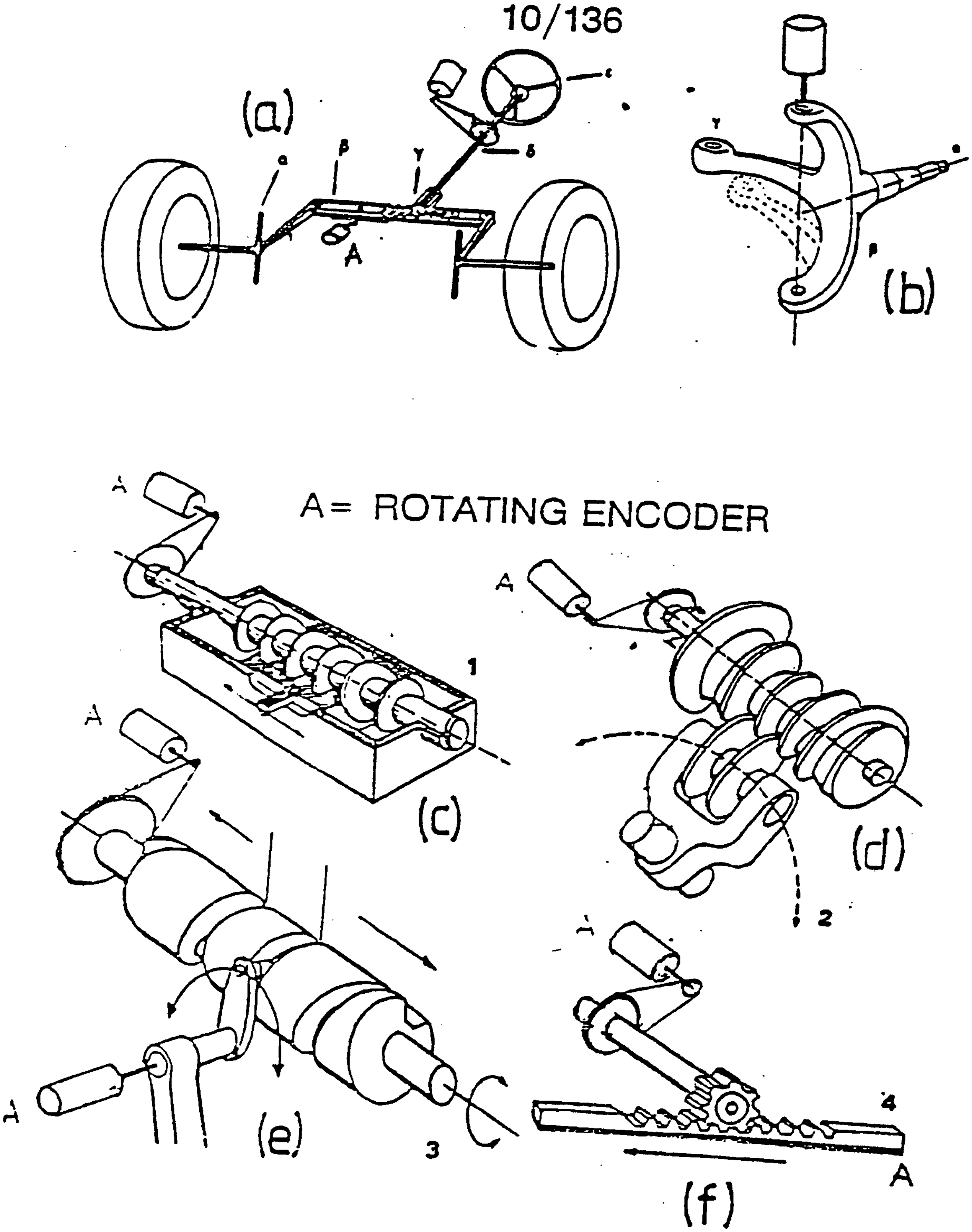
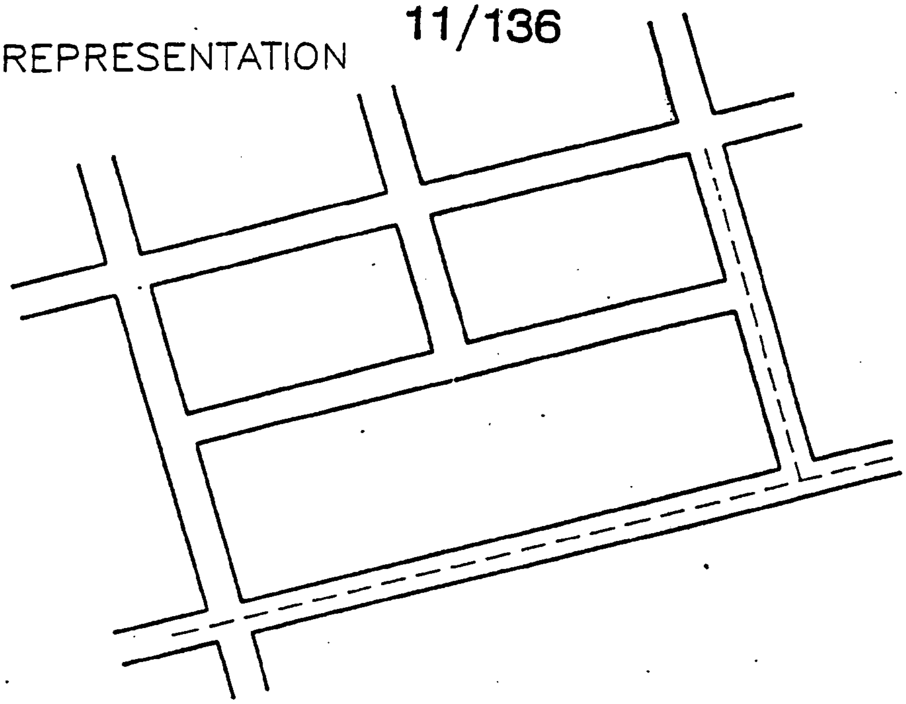


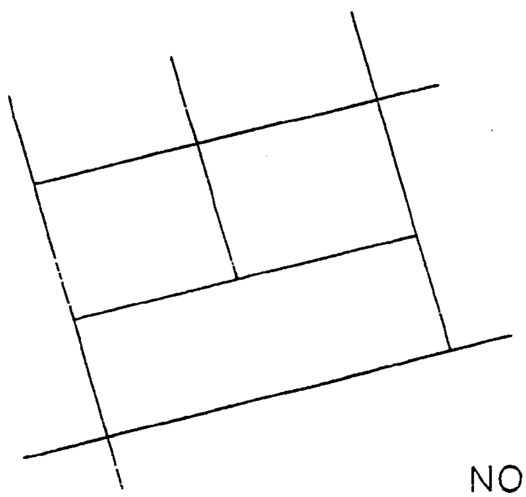
FIGURE 10

SUBSTITUTE SHEET

(A) REAL REPRESENTATION



(B) TOPOLOGICAL REPRESENTATION



(C) TOPOLOGICAL DATA

1 – 2, 6
2 – 3, 5, 1
3 – 4, 2
4 – 8, 5, 3
5 – 4, 6, 2
6 – 5, 7, 1
7 – 8, 6
8 – 7, 6

NODE

NODES CONNECTED IN A RATIONAL ORDER (e.g. CLOCKWISE) FROM A HORIZONTAL DATUM

FIGURE 11

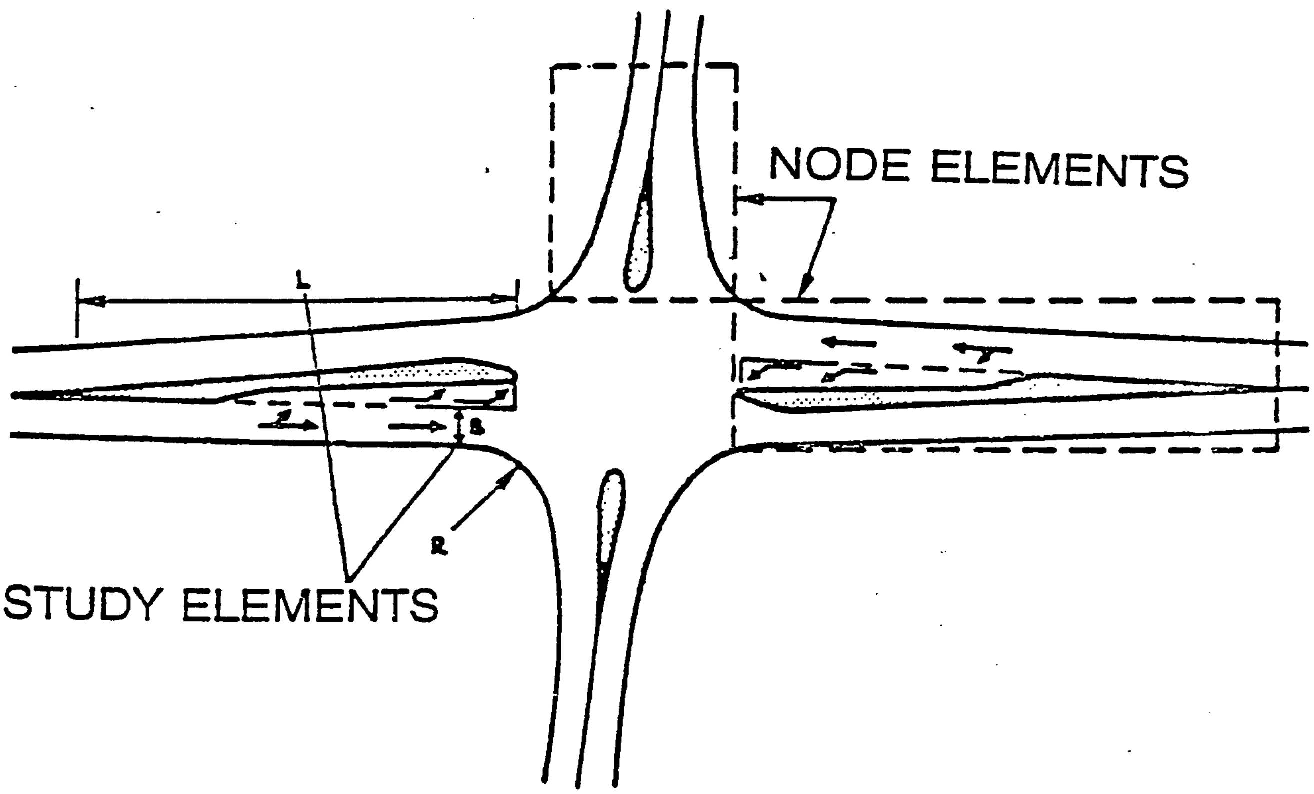


FIGURE 12

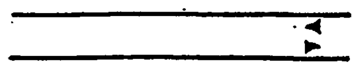
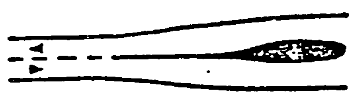
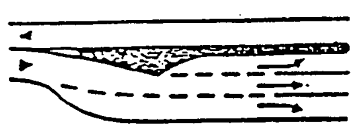
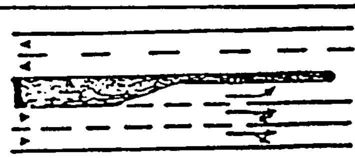
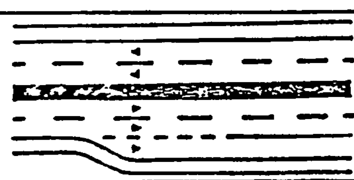
I/N	ELEMENT	AREA OF USE
1		Nodes of * connecting roads with collecting ones * inter-connecting roads
2		Nodes of * inter-collecting roads * important collecting roads with connecting ones
3		Nodes of * collecting roads with thoroughfares * thoroughfares between them Insignificant circulation of those deviating to the right side of a thoroughfare
4		Nodes of * collecting roads with thoroughfares * thoroughfares between them Significant circulation of those deviating from the thoroughfare (regulated by signs)
5		Nodes of * thoroughfares between them (of 4 lanes)
6		Nodes of * Highways with thoroughfares * Highways between them

FIGURE 13

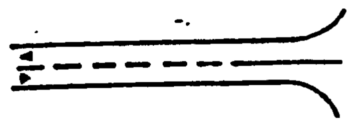
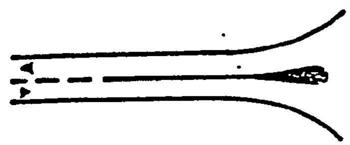
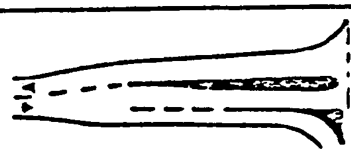
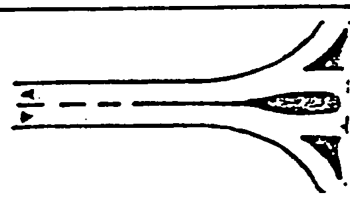
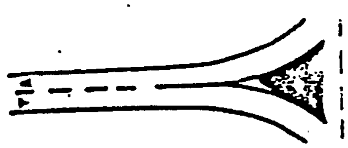
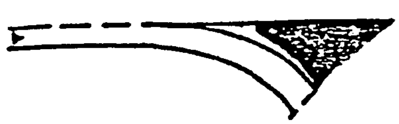
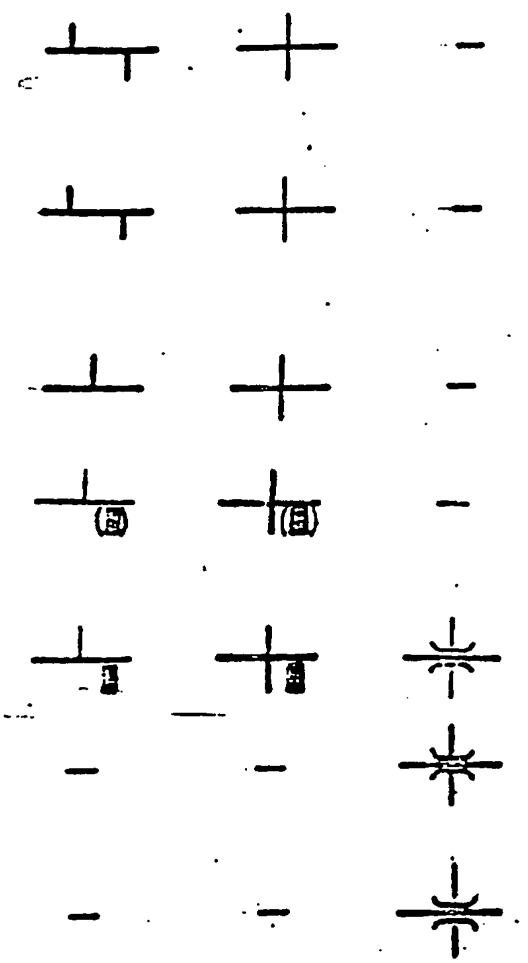
I/N	ELEMENT	AREA OF USE
7		Nodes of * inter-connecting roads * connecting roads with collecting ones
8		Nodes of * connecting roads with collecting ones * inter-collecting roads* possibly, secondary collecting roads with thoroughfares
9		Nodes of * collecting roads with thoroughfares
10		Nodes of * collecting roads with thoroughfares * thoroughfares between them
11		Nodes of * collecting roads with onwwy thoroughfares * squares forming a circle
12		Nodes of * thoroughfares with highways * highways between them

FIGURE 14

15/136



ROAD TYPE	NODE TYPES	CIRCULATION MODE
Connecting to connecting		* Free (priority)
Connecting to collecting		* STOP sign at the connecting road * Possibly free circulation in case of good visibility
Collecting to collecting		* Circulation regulated by median strips
Collecting to thoroughfare		* Circulation regulated by median strips * Possibly light sign
Thoroughfare to thoroughfare		* Light sign * Possibly two levels
Thoroughfare to highway		* Two levels
Highway to Highway		* Two or more levels

FIGURE 15

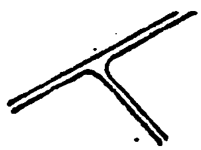
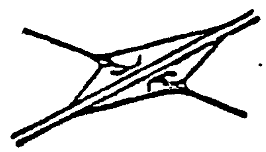
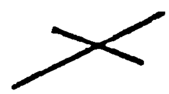
NUMBER OF LEVELS	One	Two	More
			
NUMBER OF ROADS	Three	Four	More
			
ROAD CONNECTION CATEGORY	Connecting to connecting to thoroughfare (one level)	Thoroughfare to thoroughfare to highway (1-2 levels)	Highway to highway (2 or more levels)
TRAFFIC FLOW	Interrupted	Combination of interrupted and continuous	Continuous

FIGURE 16

Branches	LEVEL 1	LEVEL 2	LEVEL 3
3	* Simple branch (no movement in angle) * Y-type node (with small movement in angle) * T-type connection * Star-type node	* Trumpet-type node * Double trumpet-type node * Combination of the above	* Triangle-type node * Star-type node
4	* Crossroad	* Rhombus-type node (diamond) * Half-clover-type node * Circle-type node	* Clover-type node * Circle-type node * Propeller-type node * Turbine-type node
More	* Circle-type node * Rectangle-type node	* Circle-type node	----

FIGURE 17

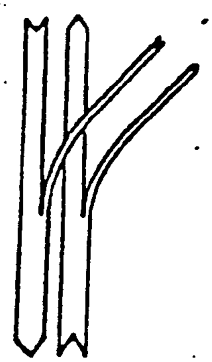
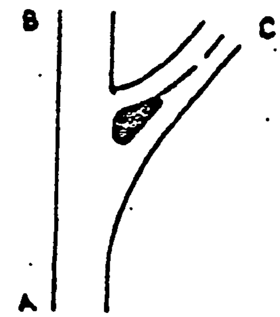
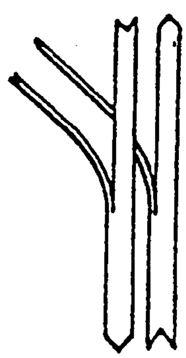
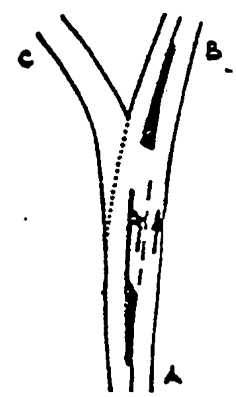
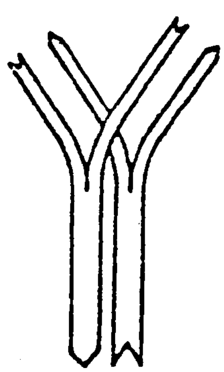
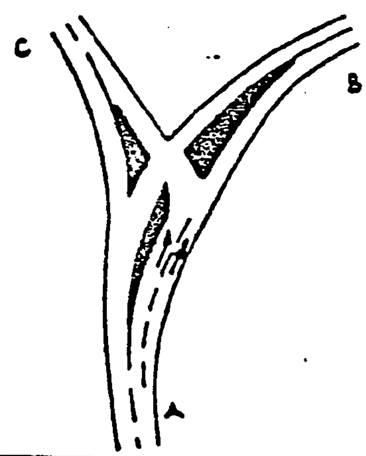
TYPE	DESCRIPTION	Contin. Traffic	Interrupt Traffic	EXAMPLE
SIMPLE BRANCH WITH NO MOVEMENT IN ANGLE		A B B A A C	C A	
		A B B A C A	A C	
		A B B A C A	A C	

FIGURE 18

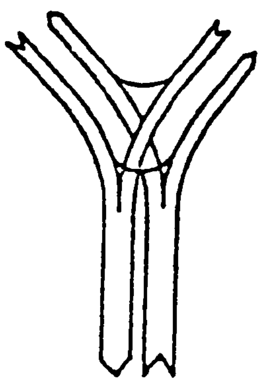
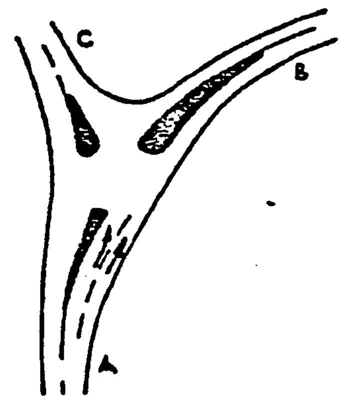
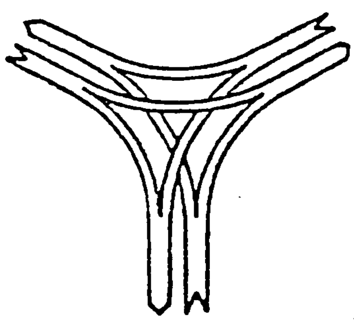
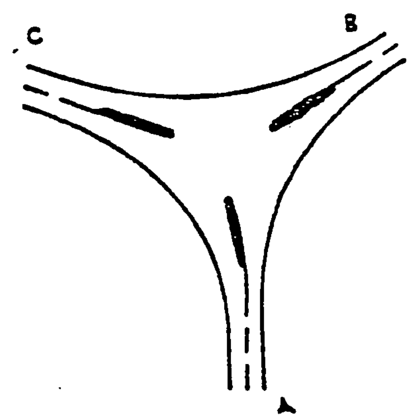
TYPE	DESCRIPTION	Cont. Traffic	Interr. Traffic	EXAMPLE
T-TYPE Road Connection		A B B A C A B C	A C C B	
STAR-TYPE NODE		A B B C C A	A C C B B A	

FIGURE 19

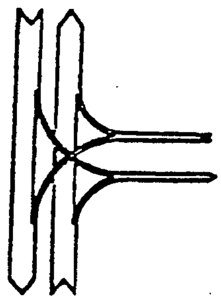
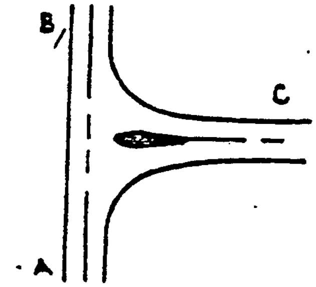
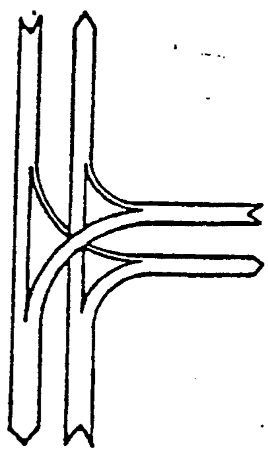
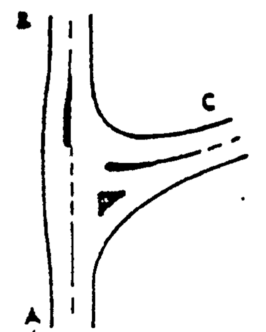
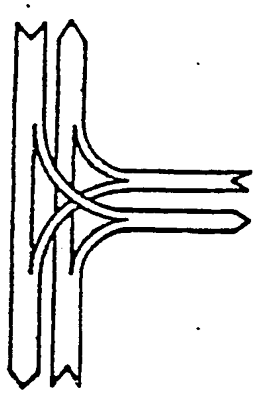
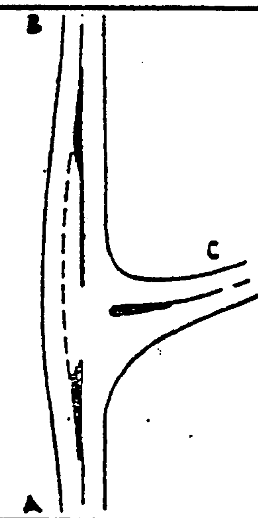
TYPE	DESCRIPTION	Contin. Traffic	Interrupt Traffic	EXAMPLE
T- TYPE ROAD CONNECTION		A B B A A C	C A B C C B	
		A B B A A C C B ή	C A B C C B	
		A B B A A C C B ή	C A B C C B	

FIGURE 20

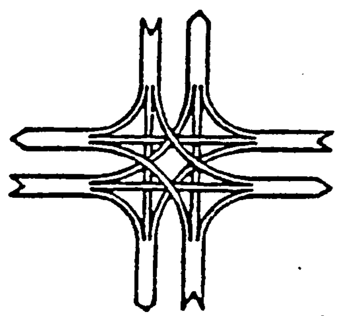
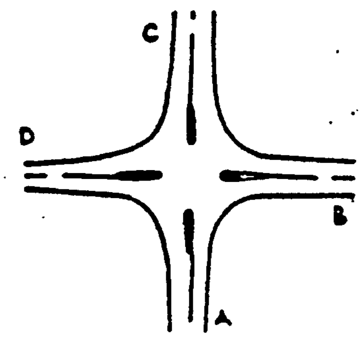
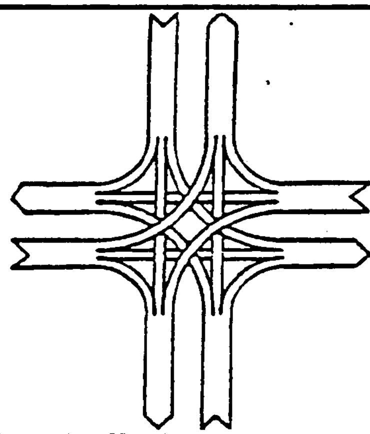
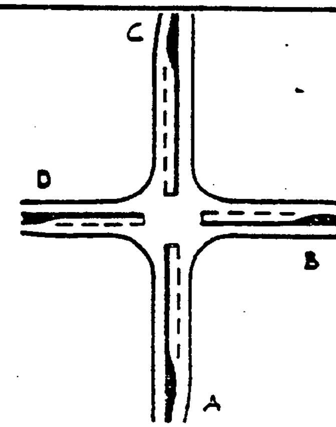
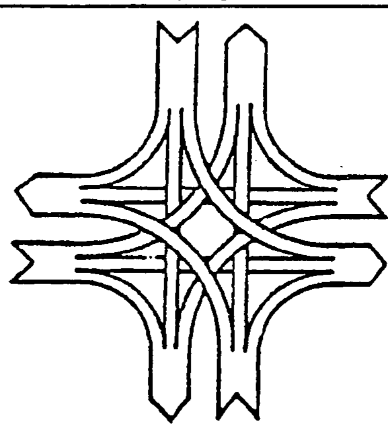
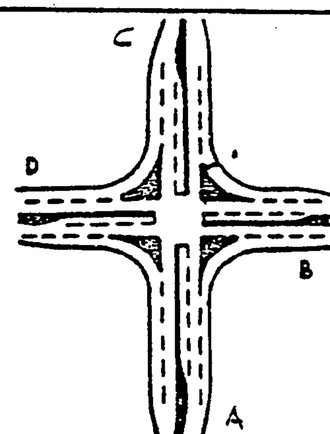
TYPE	DESCRIPTION	Contin. Traffic	Interrupt Traffic	EXAMPLE
ALL 4 BRANCHES WITH SAME TRAFFIC CAPACITY		A B B C C D D A	A C A D B D B A C A C B D B D C	
		A B A B B C C D D A	A C A D B D B A C A C B D B D C	
		A B B C C D D A	A C A D B D B A C A C B D B D C	

FIGURE 21

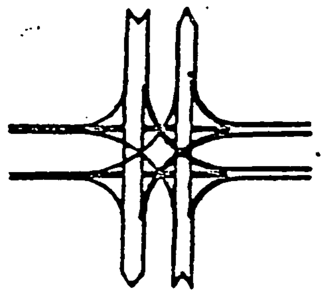
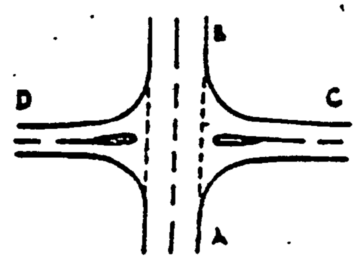
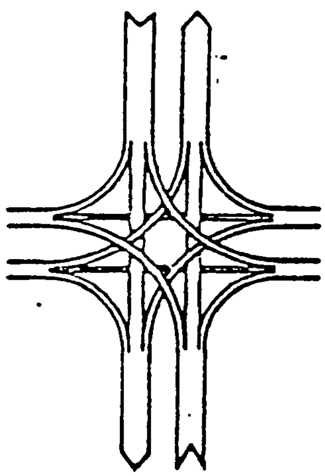
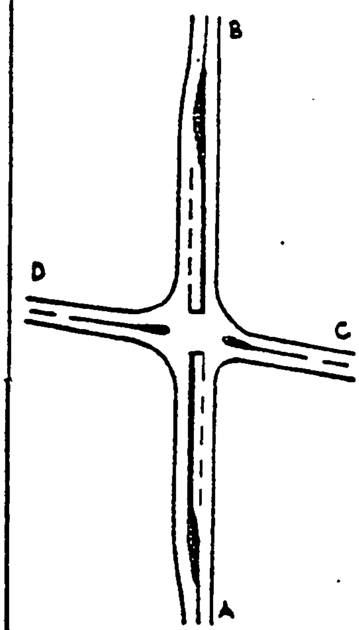
TYPE	DESCRIPTION	Contin. Traffic	Interrupt Traffic	EXAMPLE
C R O S S R O A D S		A B B A A C B D	A D D A B C C B C A D B D C D C C D	
		A B B A A C B D A B B A A C C B ή	A D B C C A C B C D D A D B D C C A B C C B	

FIGURE 22

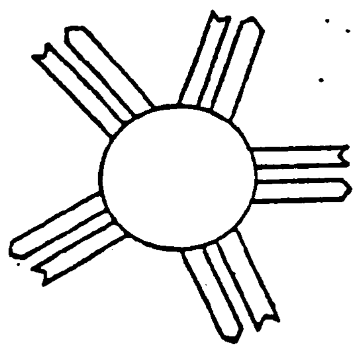
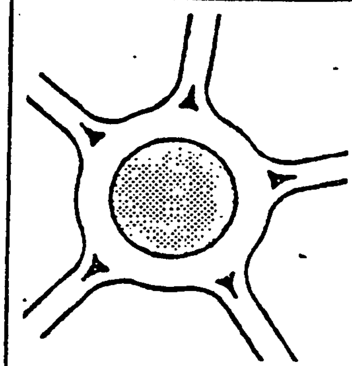
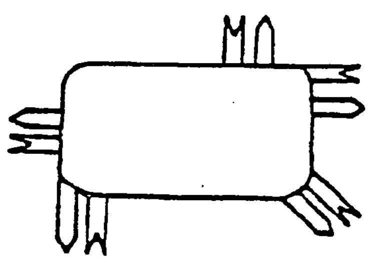
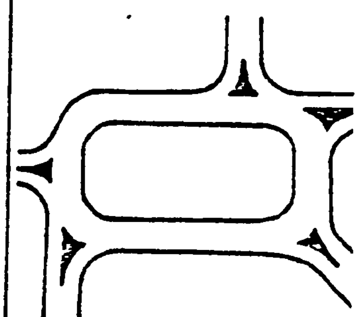
TYPE	DESCRIPTION	TRAFFIC FLOW	EXAMPLE
Circle-type node		All traffic in continuous flow	
Rectangular square-type node (movement in different directions)		All traffic in continuous flow	

FIGURE 23

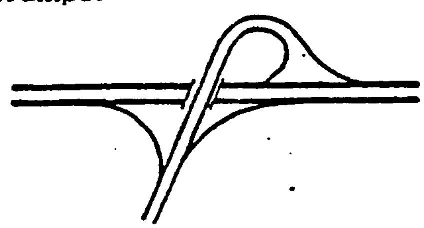
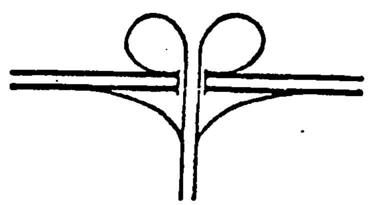
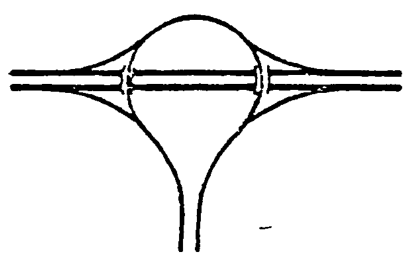
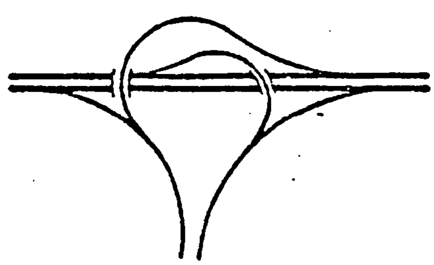
	TYPE	Number of unleveled passages	Entering manoeuvre in highways	Intersection points on highways
HIGHWAYS INTERSECTED WITH THOROUGH-FARES	Trumpet 	1	--	--
	Double Trumpet 	1	1	--
		2	--	1 entering manoeuvre
		2	--	--

FIGURE 24

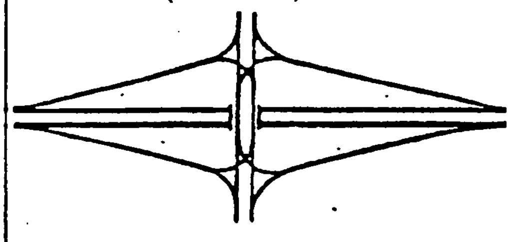
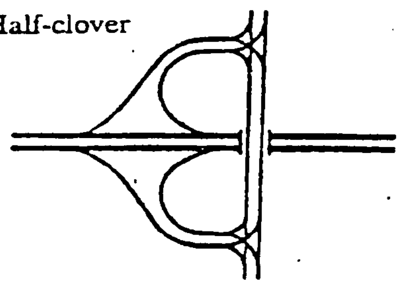
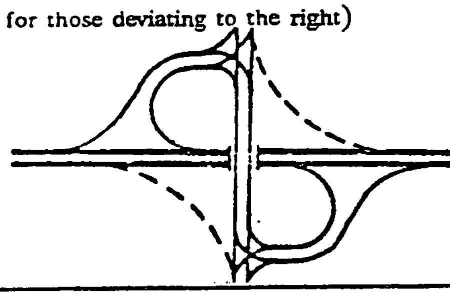
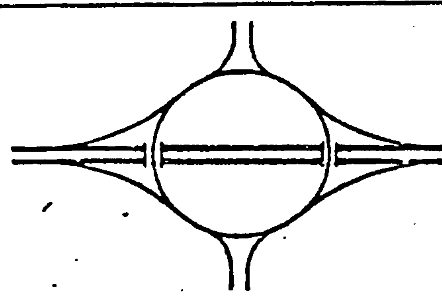
	TYPE	Number of unleveled passages	Entering manoeuvre in highways	Intersection points on highways
HIGHWAYS INTERSECTED WITH THOROUGH-FARES	Rhombus (diamond) 	1	--	6
	Half-clover 	1	--	6
	Half-clover (possibly with separated exit for those deviating to the right) 	2	--	4 manoeuvres for entering the circle
		2	--	--

FIGURE 25

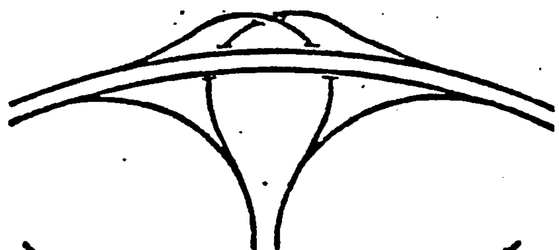
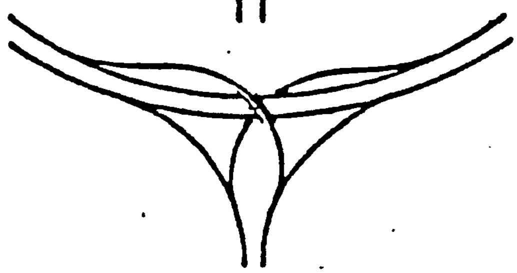
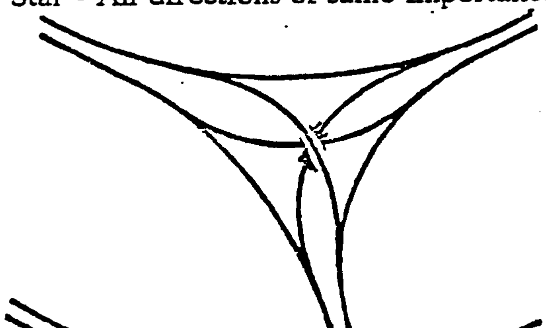
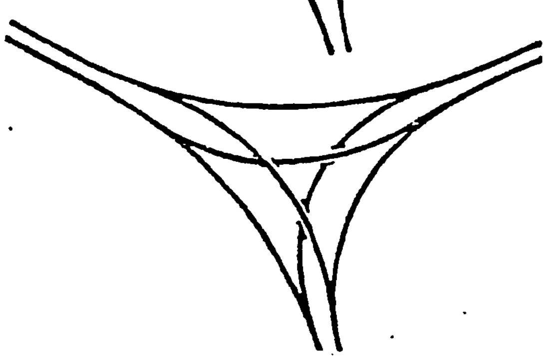
	TYPE	Number of unleveled passages	Intersection points on highways
HIGHWAYS INTERSECTED WITH HIGHWAYS	Triangle - One direction of more importance 	3	--
		2	--
	Star - All directions of same importance 	2	--
		3	--

FIGURE 26

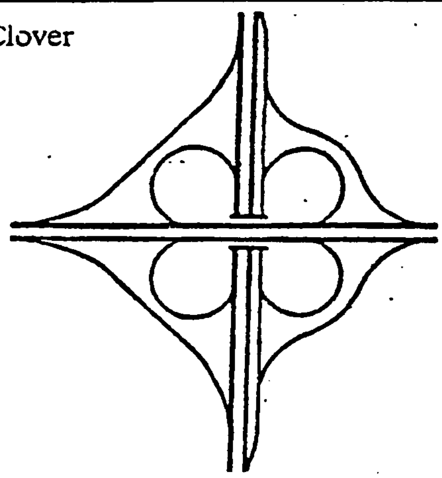
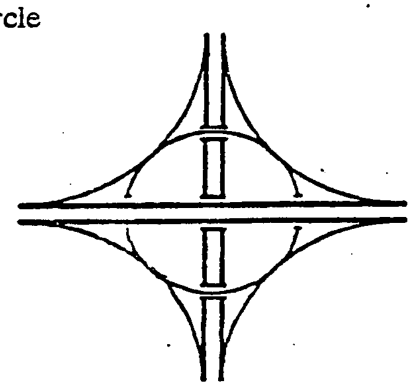
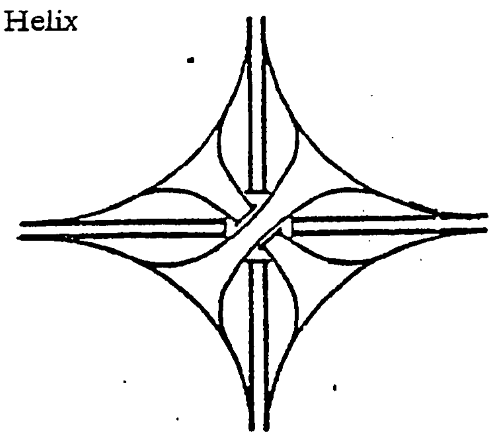
	TYPE	Number of unlevcled passages	Entering manoeuvres in highways	Moving on ramps
HIGHWAYS INTERSECTED WITH HIGHWAYS	Clover 	1	2	--
	Circle 	5	--	4
	Helix 	3	--	--

FIGURE 27

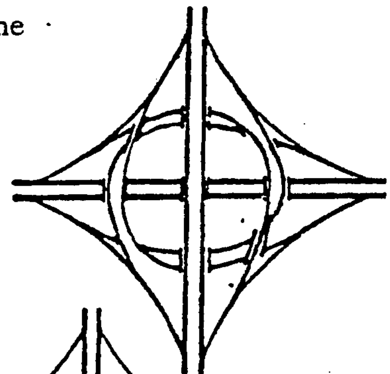
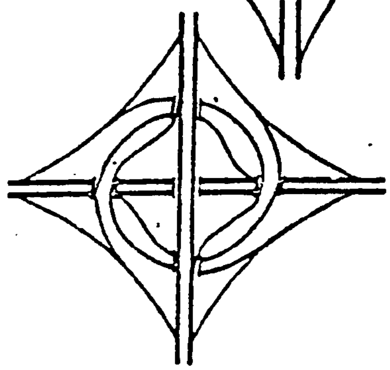
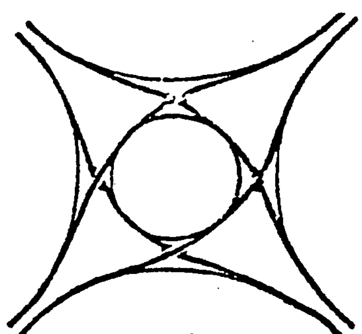
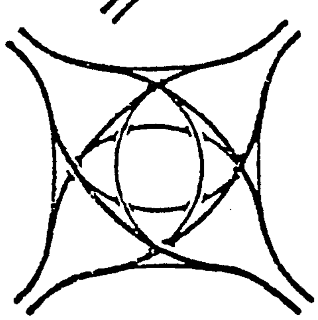
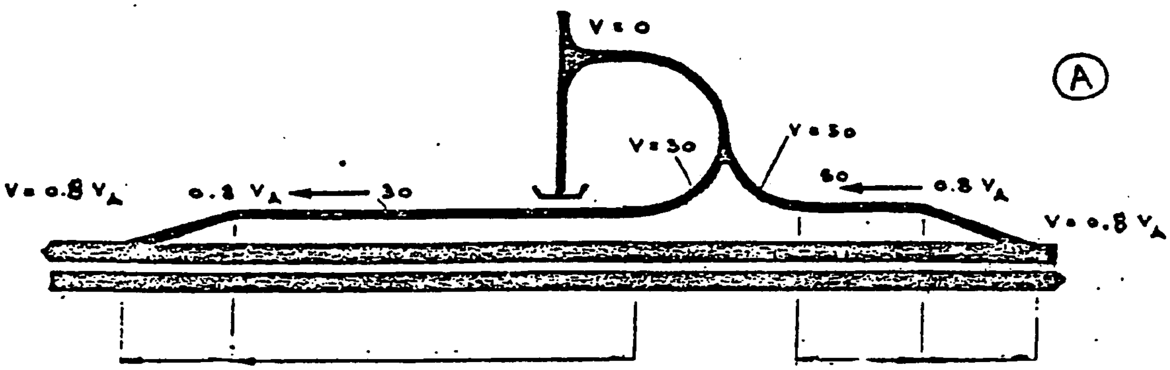
	TYPE	Number of unleveled passages	Entering manoeuvres in highways	Moving on ramps
HIGHWAYS INTERSECTED WITH HIGHWAYS	Turbine 	9	--	--
		5	--	--
	Ring (entrance from & exit to the left) 	4	4	--
		8	--	--

FIGURE 28

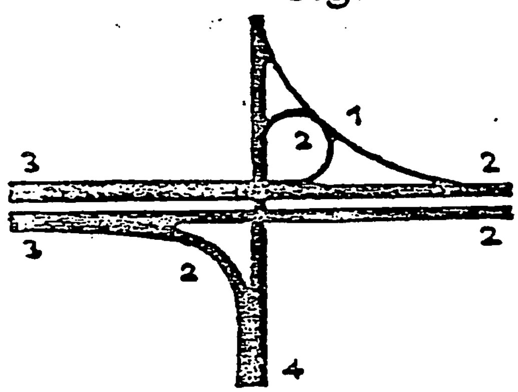
Defining the various speeds V



Merging Acceleration lane Decelaration lane

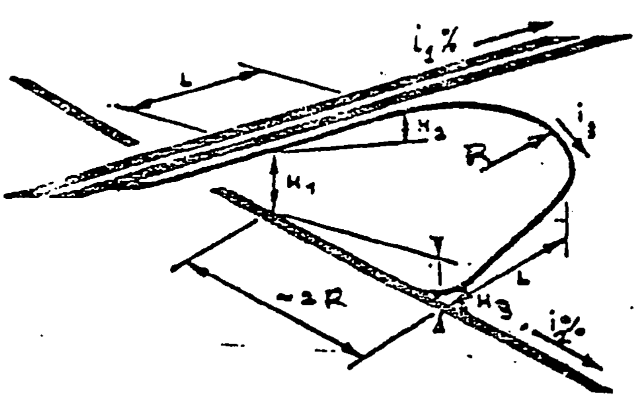
(A)

e.g. traffic lanes



(B)

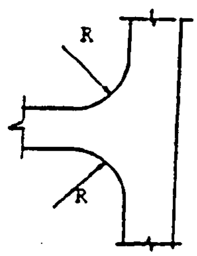
Example Difference in altitude



(Γ)

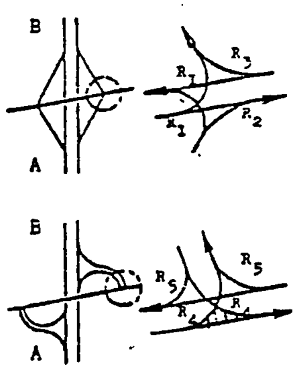
FIGURE 29

1. ORDINARY SIMPLE NODES



POSITION	RADIUS R (m) Normal	Minimum
Garage entrance	6.00	5.00
Connecting roads	6.00	6.00
Collecting roads	8.00	6.00
Thoroughfares:		
* inside inhabited areas	10.00	8.00
* outside inhabited areas	20.00	10.00

2. SECONDARY NODES ON HIGHWAYS' INTERCONNECTIONS



POSITION	RADIUS R (m) Normal	Minimum
Left-handed turn R_1	30.00	15.00
Right-handed turn		
from AB R_2	30.00	20.00
to AB R_3	75.00	50.00
Left-handed turn R_4	20.00	15.00
Right-handed turn R_5	25.00 to 45.00	15.00

FIGURE 30

TYPE OF SLOPE	Slope percentage (%) Minimum	Maximum
Longitudinal slope (i)	0.5	4.0
Transversal slope (e)	1.0	7.0
Slope difference (m)	--	8.0
Longitudinal slopes on ramps (access in highways)		
* without go-slow lanes	--	4.0
* with go-slow ascenting lanes	--	6.0
* with go-slow descenting lanes	--	8.0

FIGURE 31

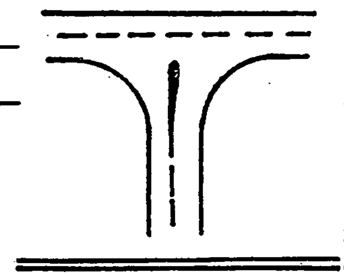
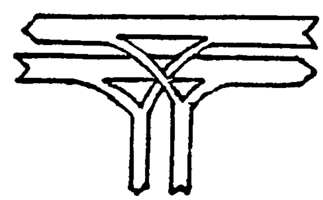
NODE CODE NUMBER	55					
SYMBOL	TAU					
GEOMETRY						
FLOW DIAGRAM						
ENTRY BRANCH (NODE)	58	58	33	33	44	44
EXIT BRANCH (NODE)	44	33	58	44	58	33
DISTANCE TRAVELLED INSIDE	35	20	25	50	30	50
PERIOD OF TOPOGRAPHIC ELEMENTS RECEIVING	5	5	5	5	5	5
AVAILABLE WIDTH 0 METRES	1	1	1	2	1	2
QUALITY IN 0 METRES	7	7	7	8	7	8
LONGITUDINAL SLOPE IN 0 METRES	+5°	+5°	+5°	0	+5°	0
TRANSVERSAL SLOPE IN 0 METRES	+2°	-1°	+2°	0	-1°	0
CURVING IN 0 METRES	-0.2	+0.2	-0.1	0	+0.1	0
AVAILABLE WIDTH 5 METRES						
QUALITY IN 5 METRES						
LONGITUDINAL SLOPE IN 5 METRES						
TRANSVERSAL SLOPE IN 5 METRES				E		
CURVING IN 5 METRES				T		
AVAILABLE WIDTH 10 METRES				C.		
QUALITY IN 10 METRES						

FIGURE 32

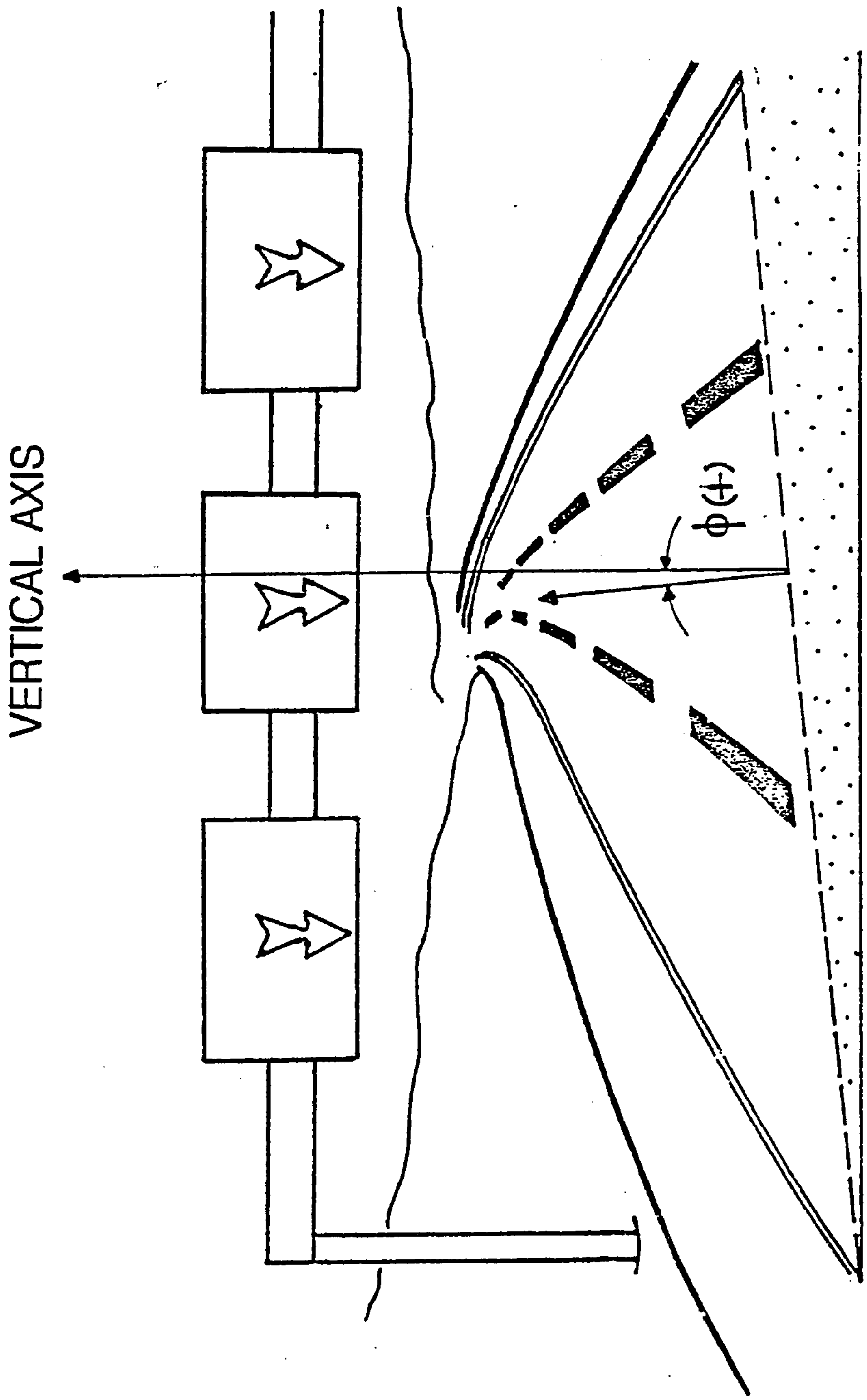


FIGURE 33

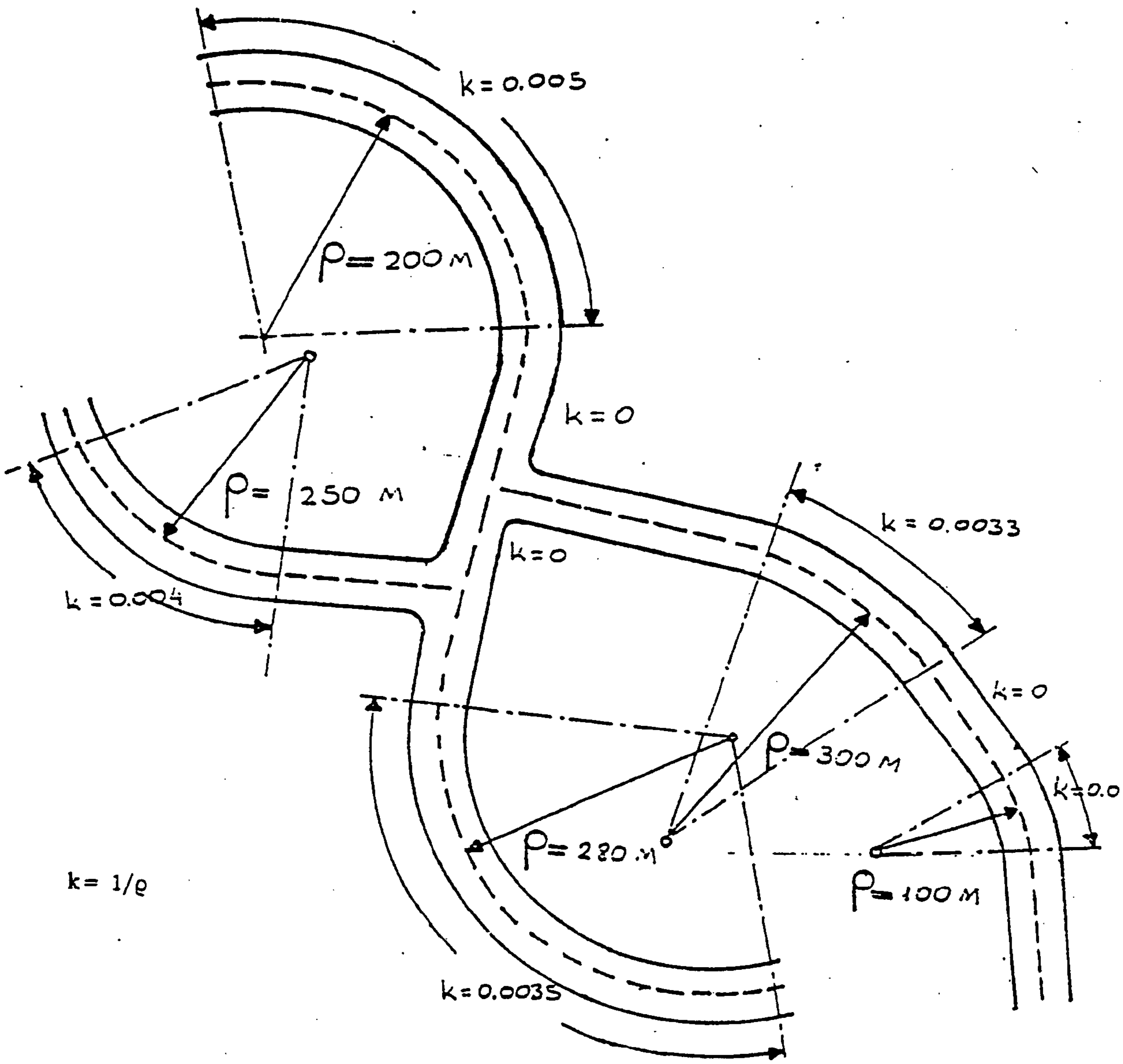
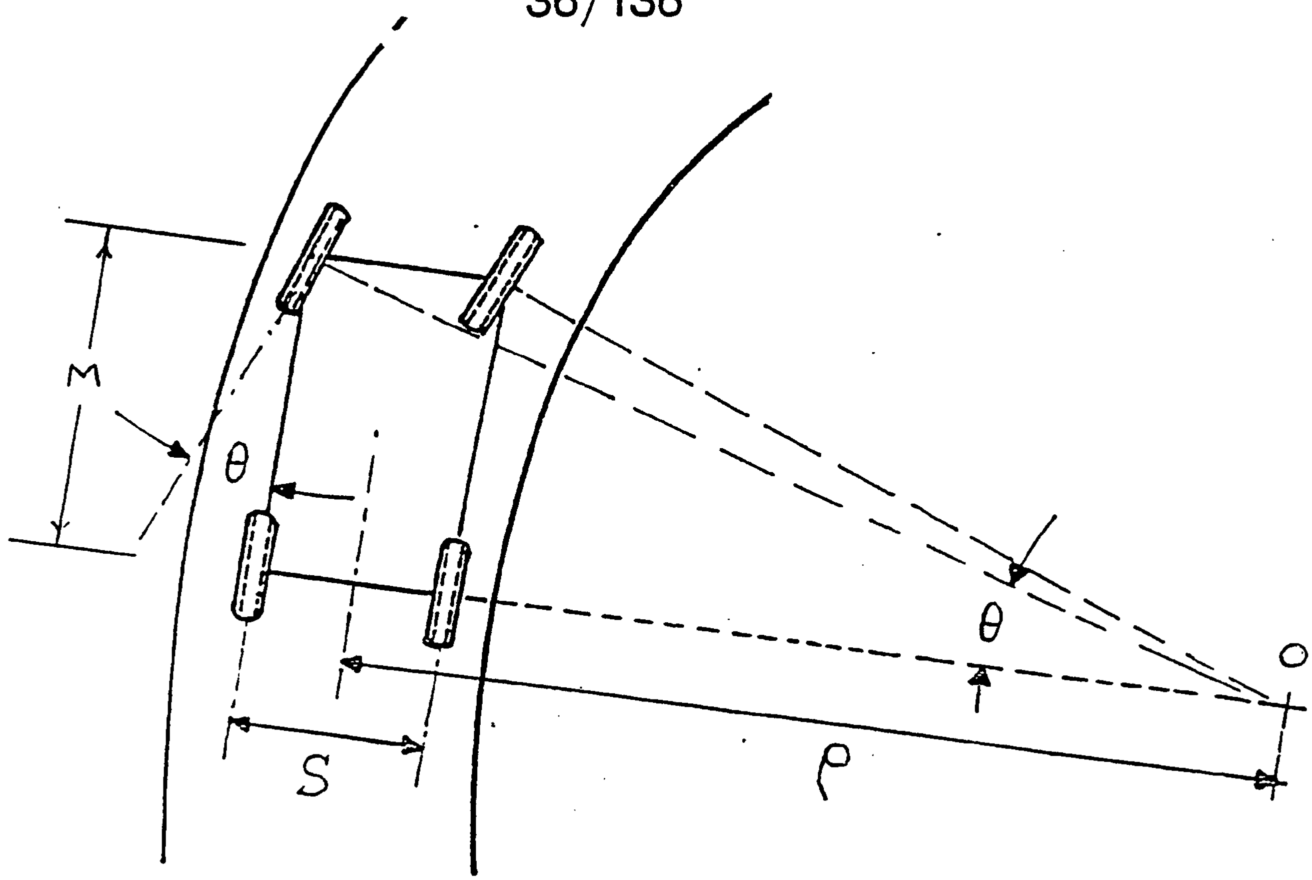

k=0.005
ρ= 200 M
k=0
ρ= 250 M
k=0.0033
k=0
k=0.004
k=0
ρ= 300 M
k=0.01
ρ= 280 M
ρ= 100 M
k= 1/ρ
k=0.0035

FIGURE 34

INITIAL NODE	1	55
FINAL NODE	2	63
PARTIAL COURSE LENGTH (METRES)	3	350
PERIOD OF DATA RECEIVING (METRES)	4	100
WIDTH AVAILABLE IN 0 COURSE METRES	5	2
QUALITY IN 0 COURSE METRES	6	8
TRANSVERSAL SLOPE IN 0 COURSE METRES	7	+5
LONGITUDINAL SLOPE IN 0 COURSE METRES	8	0
CURVING IN 0 COURSE METRES	9	+0.1
WIDTH AVAILABLE IN 100 METRES	10	2
QUALITY IN 100 METRES	11	8
TRANSVERSAL SLOPE IN 100 METRES	12	+5
LONGITUDINAL SLOPE IN 100 METRES	13	0
CURVING IN 100 METRES	14	+0.001
WIDTH AVAILABLE IN 200 METRES	15	2
ROAD SURFACE QUALITY IN 200 METRES	16	8
TRANSVERSAL SLOPE IN 200 METRES	17	+2
LONGITUDINAL SLOPE IN 200 METRES	18	0
CURVING IN 200 METRES	19	+0.001
WIDTH AVAILABLE IN 300 METRES	20	2
ROAD SURFACE QUALITY IN 300 METRES	21	9
TRANSVERSAL SLOPE IN 300 METRES	22	+2
LONGITUDINAL SLOPE IN 300 METRES	23	0
CURVING IN 300 METRES	24	+0.001
WIDTH AVAILABLE AT THE END	25	3
QUALITY AT THE END	26	8
TRANSVERSAL SLOPE AT THE END	27	+2
LONGITUDINAL SLOPE AT THE END	28	0
CURVING AT THE END	29	-0.2
INITIAL NODE	30	55
FINAL NODE	31	68
PARTIAL COURSE LENGTH	32	420

FIGURE 35



ρ = curvature radius
0 = rotation centre

$\rho = M.\cot\theta - S/2 \quad k = 1/\rho$

FIGURE 36

REGULATORY SIGNS (P)

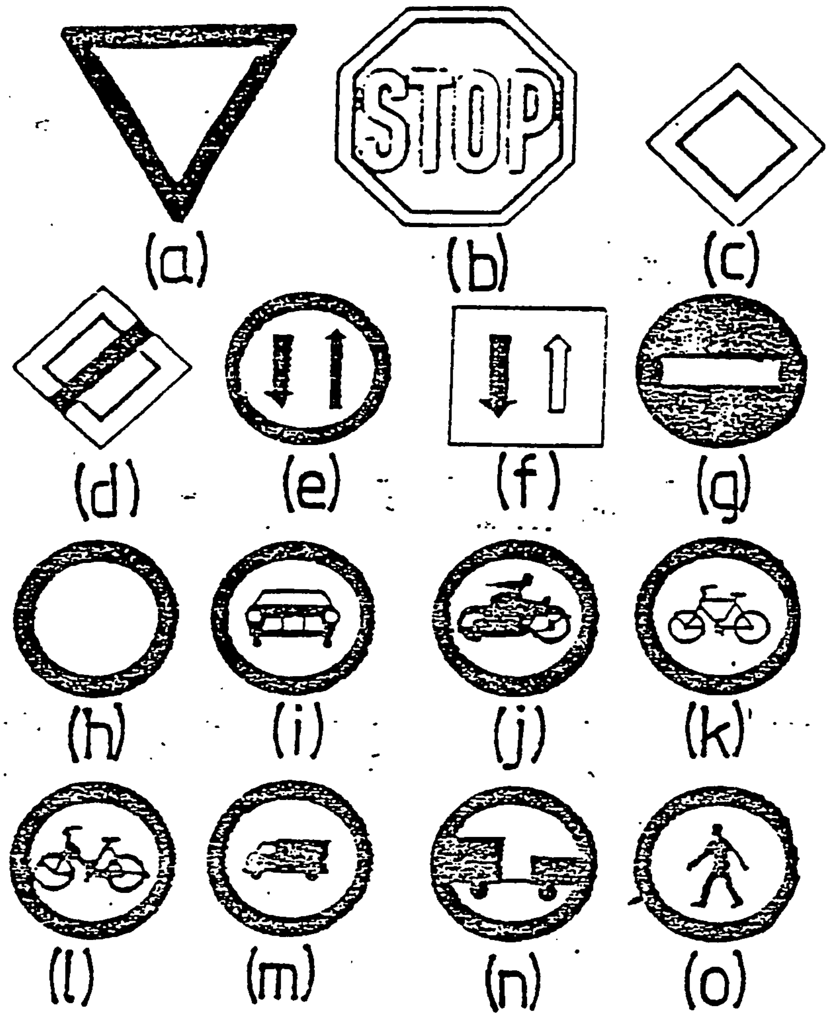
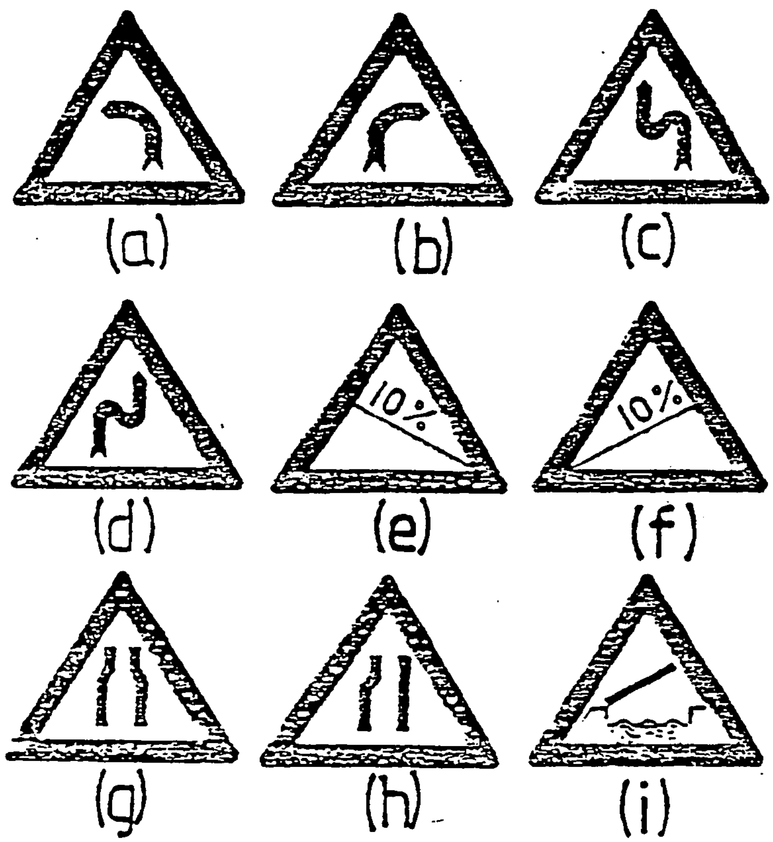


FIGURE 37

ALARM SIGNS (K)



(a) (b) (c) (d) (e) (f) (g) (h) (i)

FIGURE 38

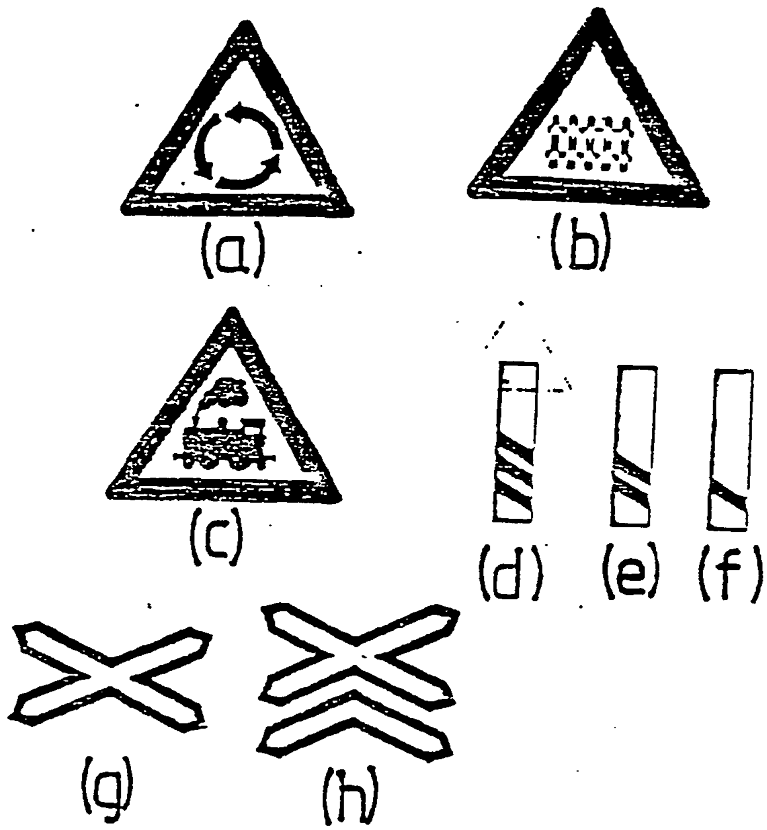


FIGURE 39

(a)

CODE OF ENTRANCE NODE	CODE OF EXIT NODE	COURSE DISTANCE	LOCATION CODE	DISTANCE FROM STARTING POINT	LOCATION CODE	DISTANCE FROM STARTING POINT	LOCATION CODE	DISTANCE FROM STARTING POINT	LOCATION CODE	DISTANCE FROM STARTING POINT	LOCATION CODE	DISTANCE FROM STARTING POINT	ETC.
35	54	350	IAT	100	PHA	120	BEN	200	ΞΥΛ	220	ΚΗΠΟ	280	

BEN

(b)

68	105	30	SHELL	9834569	8:00-20:00	WASH-LUBRICANT CHANGE	PERISTERI
35	54	200	TEXACO	5519332	7:00-19:00	SUNDAYS OPEN	34, P.RALLI STR. TAVROS
56	99	120	FINA	6478032	6:00-18:00	--	HOLARGOS

(c)

CODE OF ENTRANCE NODE	CODE OF EXIT NODE	DISTANCE FROM ENTRANCE NODE	COMPANY OR OWNER NAME	PHONE NUMBER	WORKING HOURS	MESSAGE	ADDRESS

FIGURE 40

(a)

INITIAL NODE	FINAL NODE	SPECIAL VEHICLES	TIME DEPENDENCE	COURSE LENGTH	2-WAY TRAFFIC	DEPARTURE NODE	REGULATORY SIGN	DISTANCE FROM START	ALARM SIGN	DISTANCE FROM START	STREET NAME	ARRIVAL NODE	SIGN EXISTENCE	

(b)

55	63	E	T	350	D	55	P-14	100	K-1d	150	Zinonos Str.	63	S	

(c)

34	78	100	P-14	SUNDAYS 8:00-12:00	200	E-1	25TH MARCH 11:00-14:00
55	63	100	P-14	DAILY 11:00-20:00	350	S.	DAILY 6:00-24:00 EVERY 1 SEC ON-OFF

(d)

ENTRANCE NODE	EXIT NODE	DISTANCE FROM ENTRANCE	SIGN	DURATION OF VALIDITY	DISTANCE FROM ENTRANCE	SIGN	DURATION OF VALIDITY

FIGURE 41

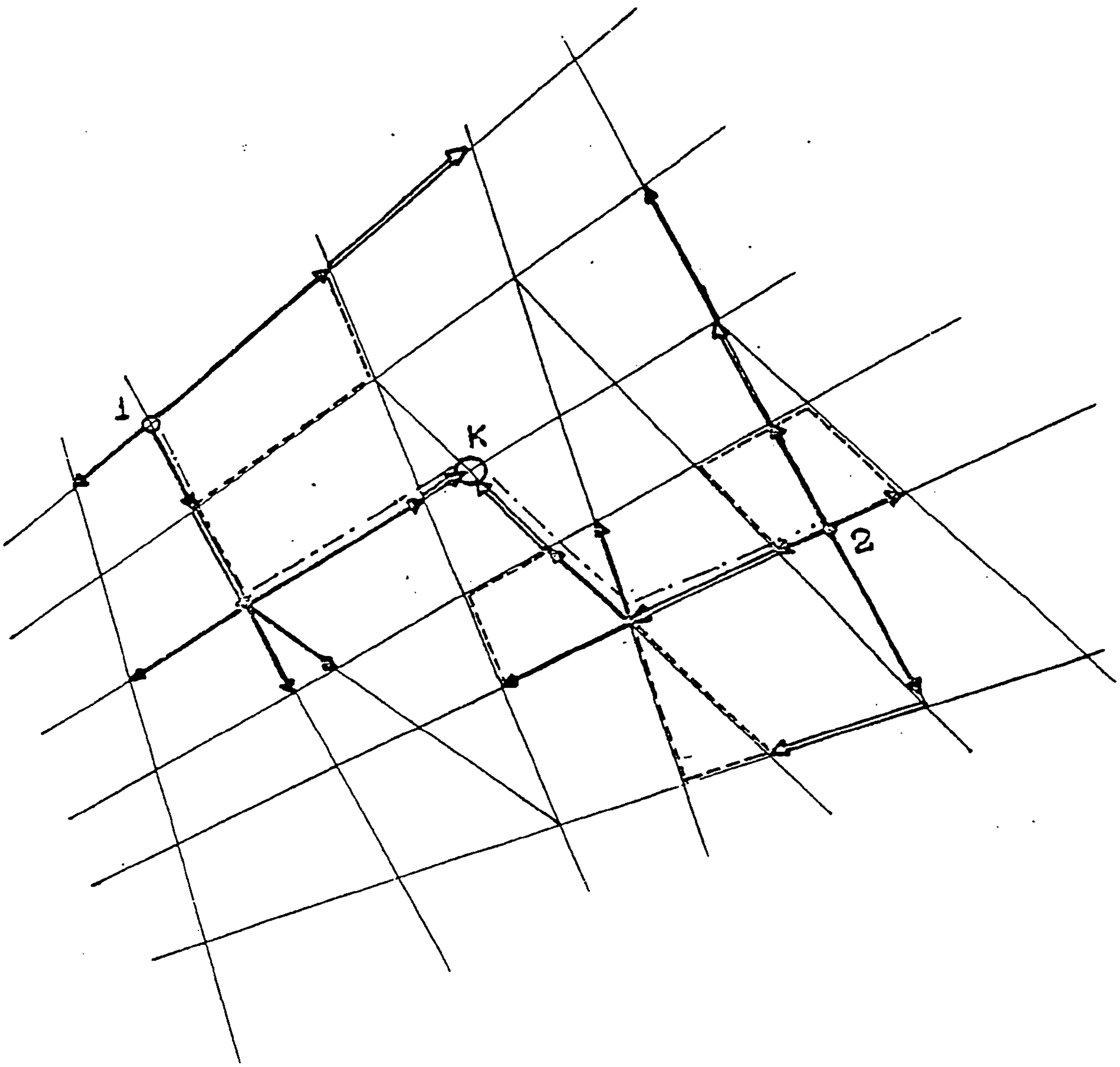


FIGURE 42

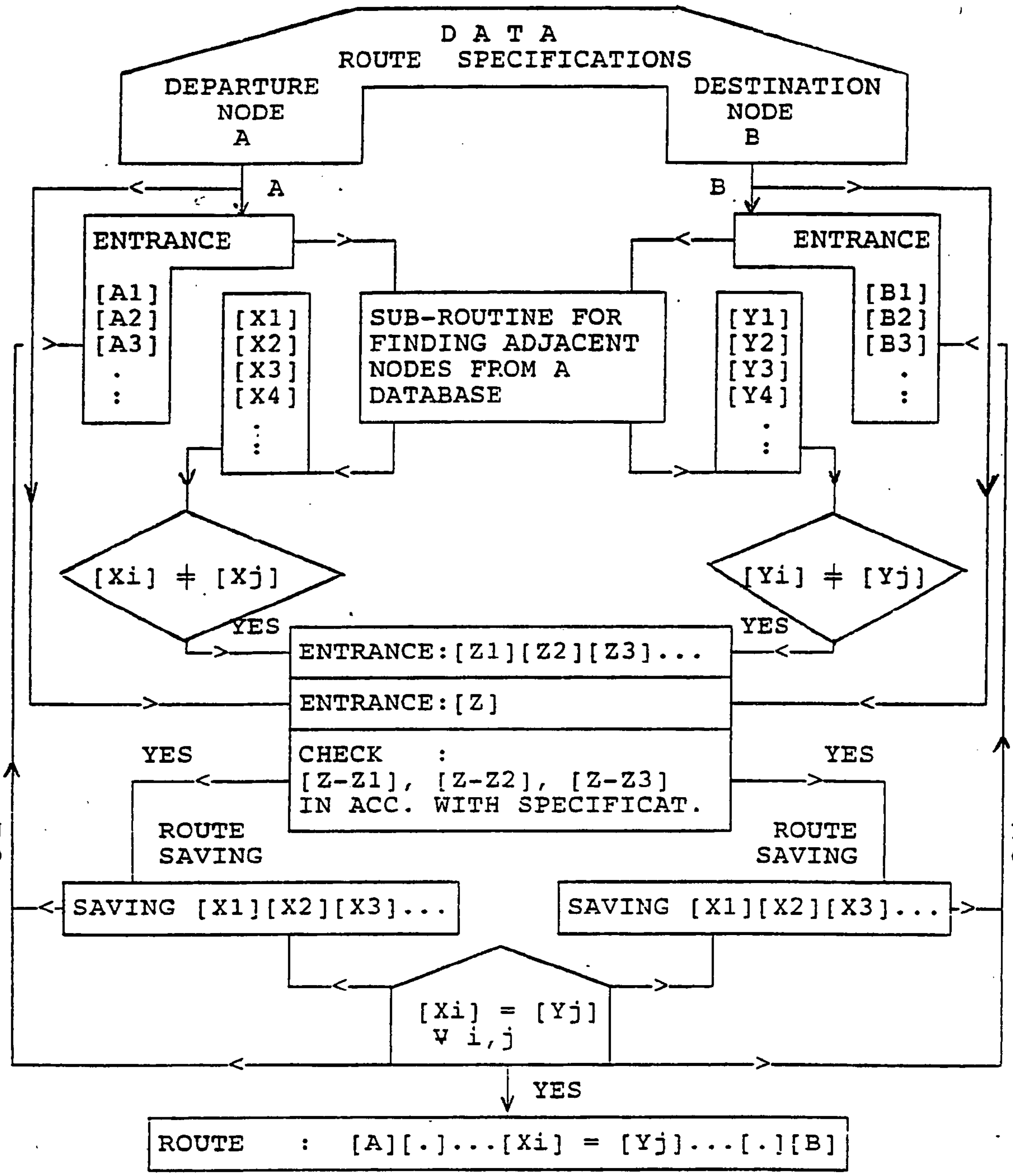
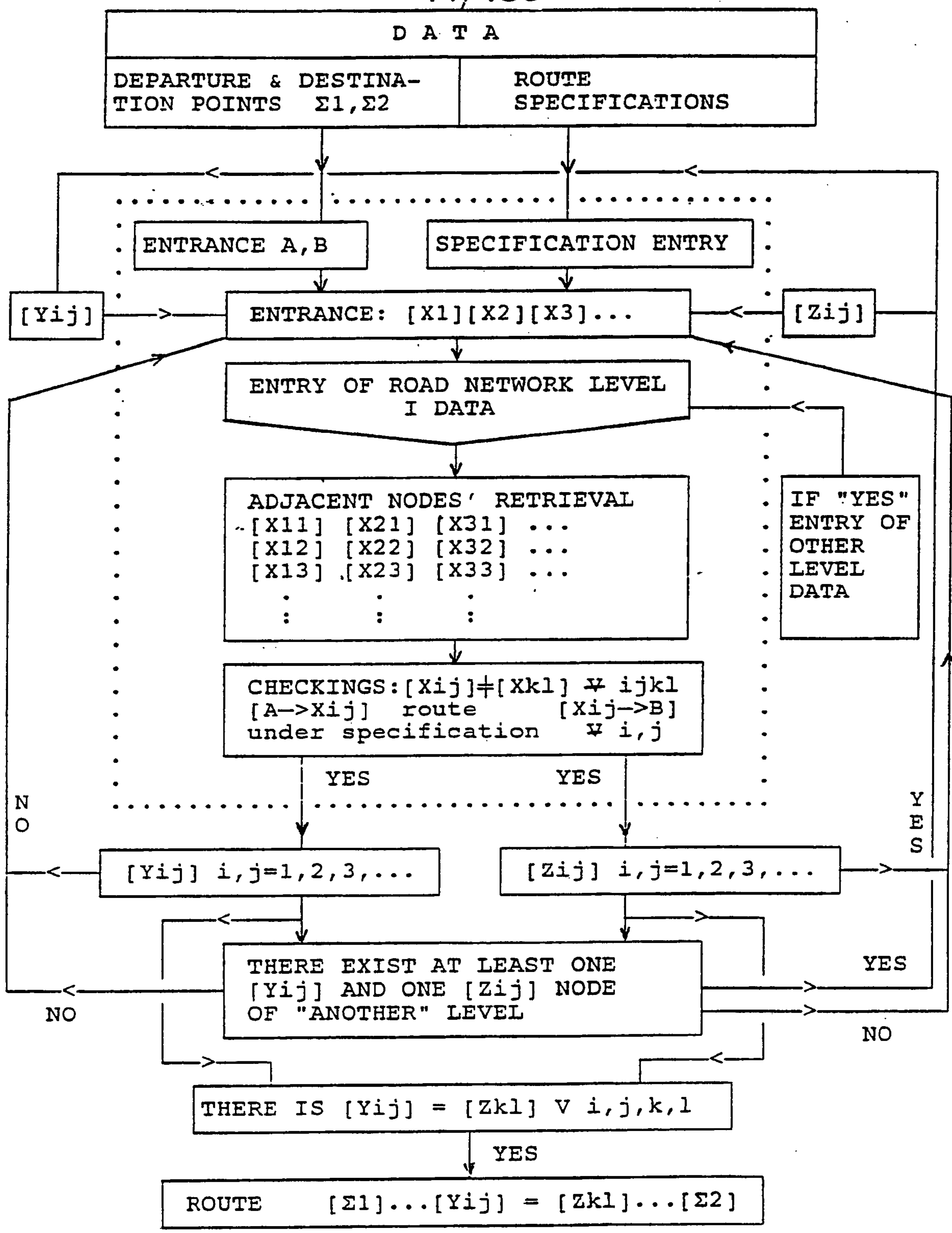

D A T A
ROUTE SPECIFICATIONS
DEPARTURE NODE A
DESTINATION NODE B
A
B
ENTRANCE
[A1]
[A2]
[A3]
[X1]
[X2]
[X3]
[X4]
SUB-ROUTINE FOR FINDING ADJACENT NODES FROM A DATABASE
[Y1]
[Y2]
[Y3]
[Y4]
ENTRANCE
[B1]
[B2]
[B3]
[Xi] ≠ [Xj]
[Yi] ≠ [Yj]
YES
YES
ENTRANCE:[Z1][Z2][Z3]...
ENTRANCE:[Z]
CHECK :
[Z-Z1], [Z-Z2], [Z-Z3]
IN ACC. WITH SPECIFICAT.
YES
YES
NO
NO
ROUTE SAVING
ROUTE SAVING
SAVING [X1][X2][X3]...
SAVING [X1][X2][X3]...
[Xi] = [Yj]
∀ i,j
YES
ROUTE : [A][.]...[Xi] = [Yj]...[.][B]

FIGURE 43



D A T A
DEPARTURE & DESTINATION POINTS Σ1,Σ2
ROUTE SPECIFICATIONS
ENTRANCE A,B
SPECIFICATION ENTRY
[Yij]
ENTRANCE: [X1][X2][X3]...
[Zij]
ENTRY OF ROAD NETWORK LEVEL I DATA
ADJACENT NODES' RETRIEVAL
[X11] [X21] [X31] ...
[X12] [X22] [X32] ...
[X13] [X23] [X33] ...
IF "YES" ENTRY OF OTHER LEVEL DATA
CHECKINGS:[Xij]≠[Xkl] ∀ ijkl
[A–>Xij] route [Xij–>B]
under specification ∀ i,j
YES
YES
NO
YES
NO
[Yij] i,j=1,2,3,...
[Zij] i,j=1,2,3,...
THERE EXIST AT LEAST ONE [Yij] AND ONE [Zij] NODE OF "ANOTHER" LEVEL
NO
YES
NO
THERE IS [Yij] = [Zkl] V i,j,k,l
YES
ROUTE [Σ1]...[Yij] = [Zkl]...[Σ2]

FIGURE 44

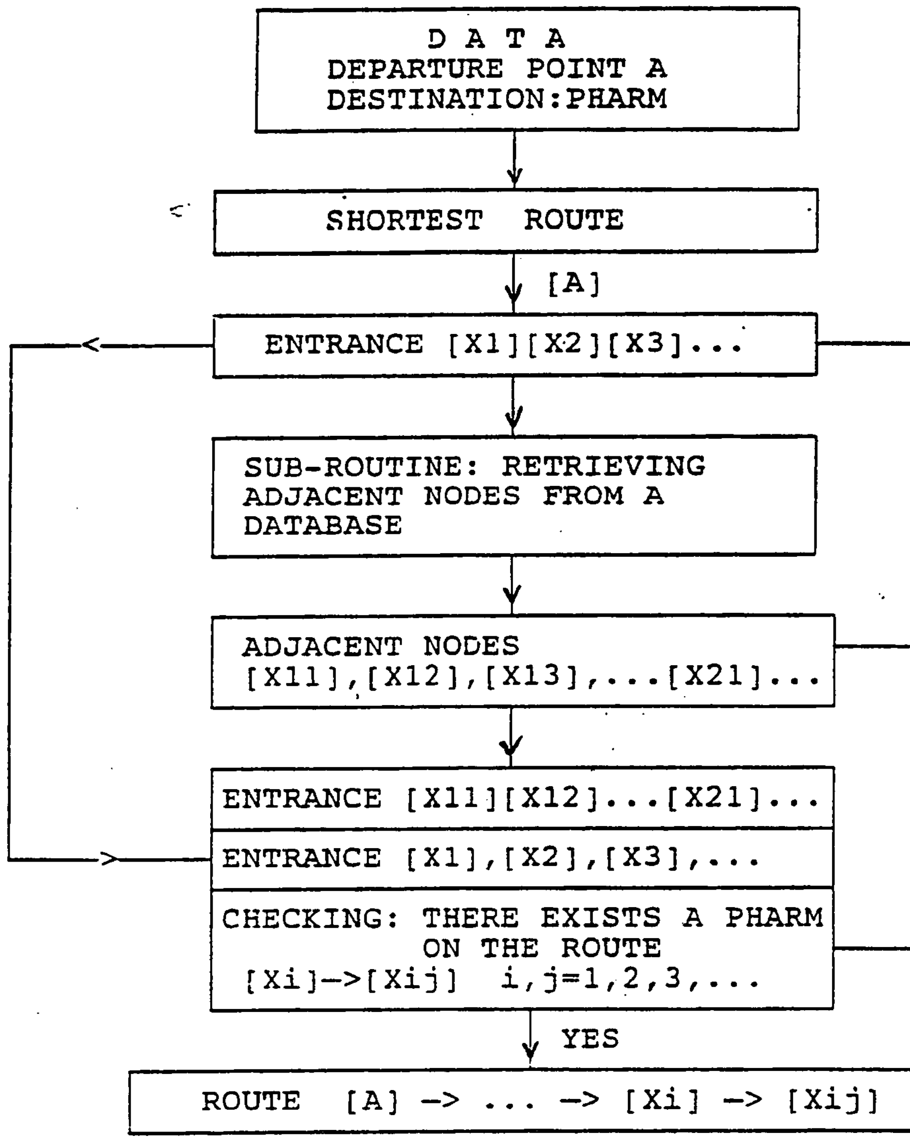

D A T A
DEPARTURE POINT A
DESTINATION:PHARM
SHORTEST ROUTE
[A]
ENTRANCE [X1][X2][X3]...
SUB-ROUTINE: RETRIEVING ADJACENT NODES FROM A DATABASE
ADJACENT NODES [X11],[X12],[X13],...[X21]...
ENTRANCE [X11][X12]...[X21]...
ENTRANCE [X1],[X2],[X3],...
CHECKING: THERE EXISTS A PHARM ON THE ROUTE [Xi]->[Xij] i,j=1,2,3,...
NO
NO
YES
ROUTE [A] -> ... -> [Xi] -> [Xij]

FIGURE 45

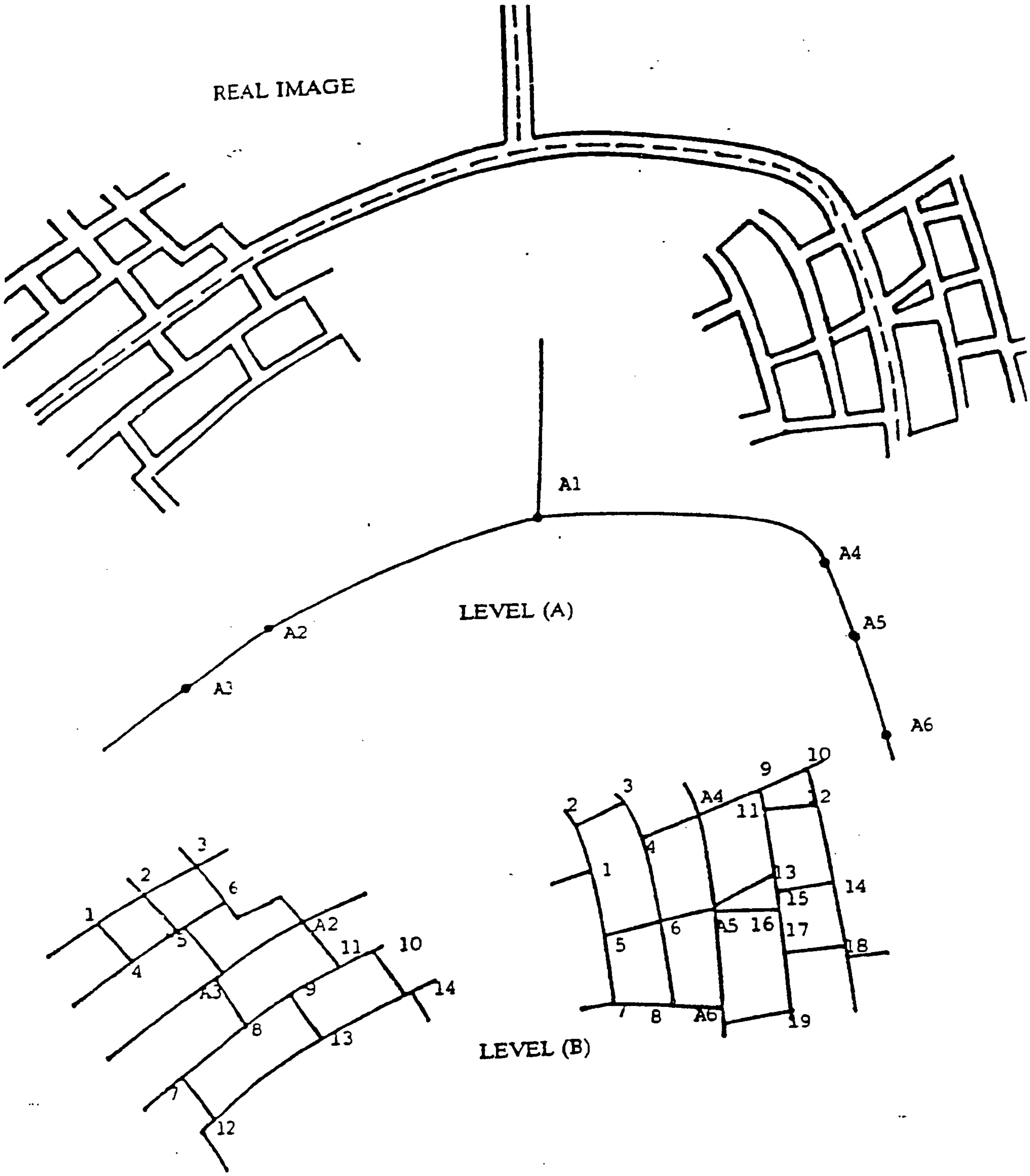

REAL IMAGE
A1
A4
LEVEL (A)
A2
A5
A3
A6
1
2
3
4
5
6
A2
A3
11
10
9
14
8
13
7
12
2
3
A4
9
10
11
12
1
4
13
14
15
5
6
A5
16
17
18
7
8
A6
19
LEVEL (B)

FIGURE 46

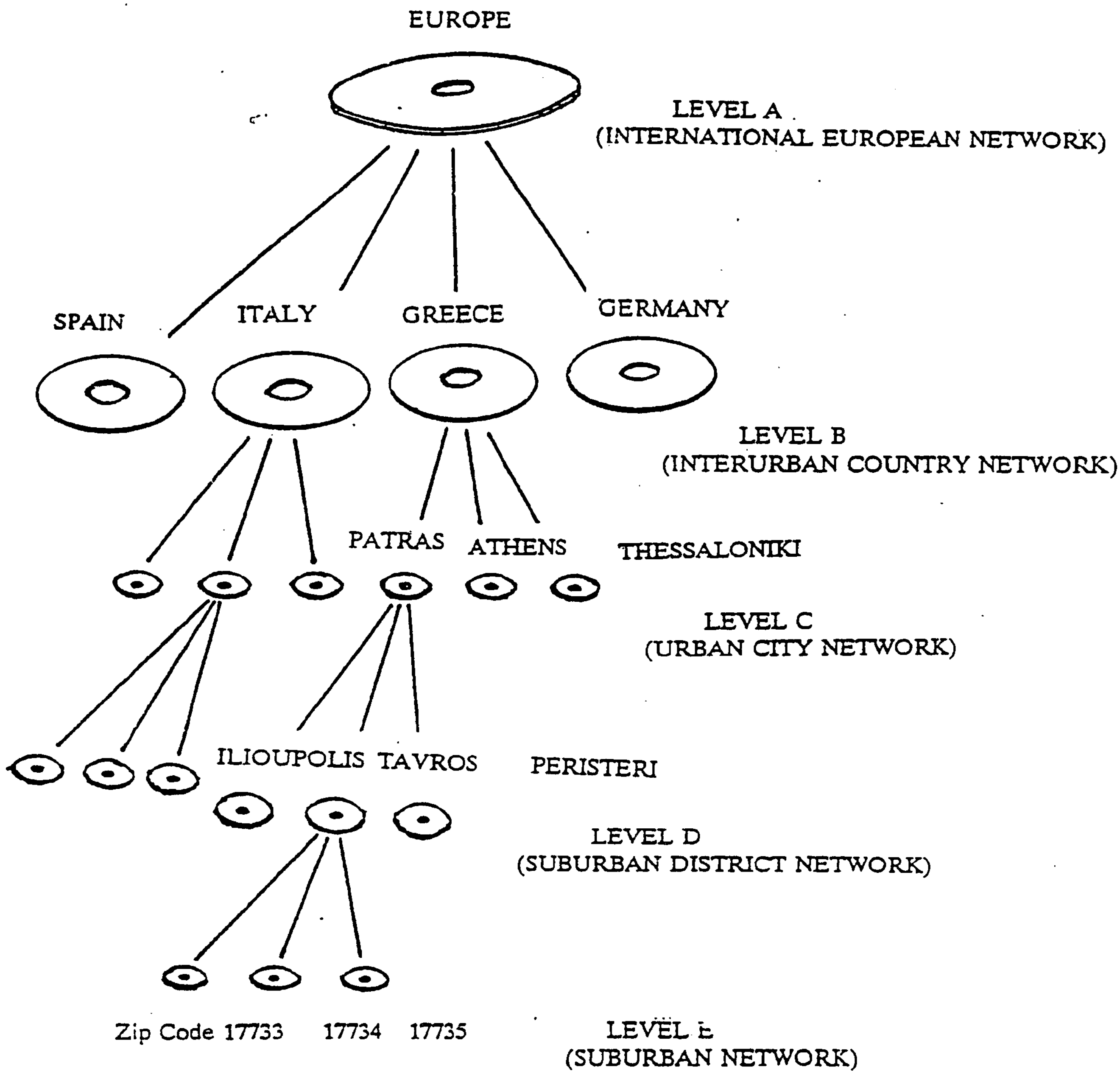
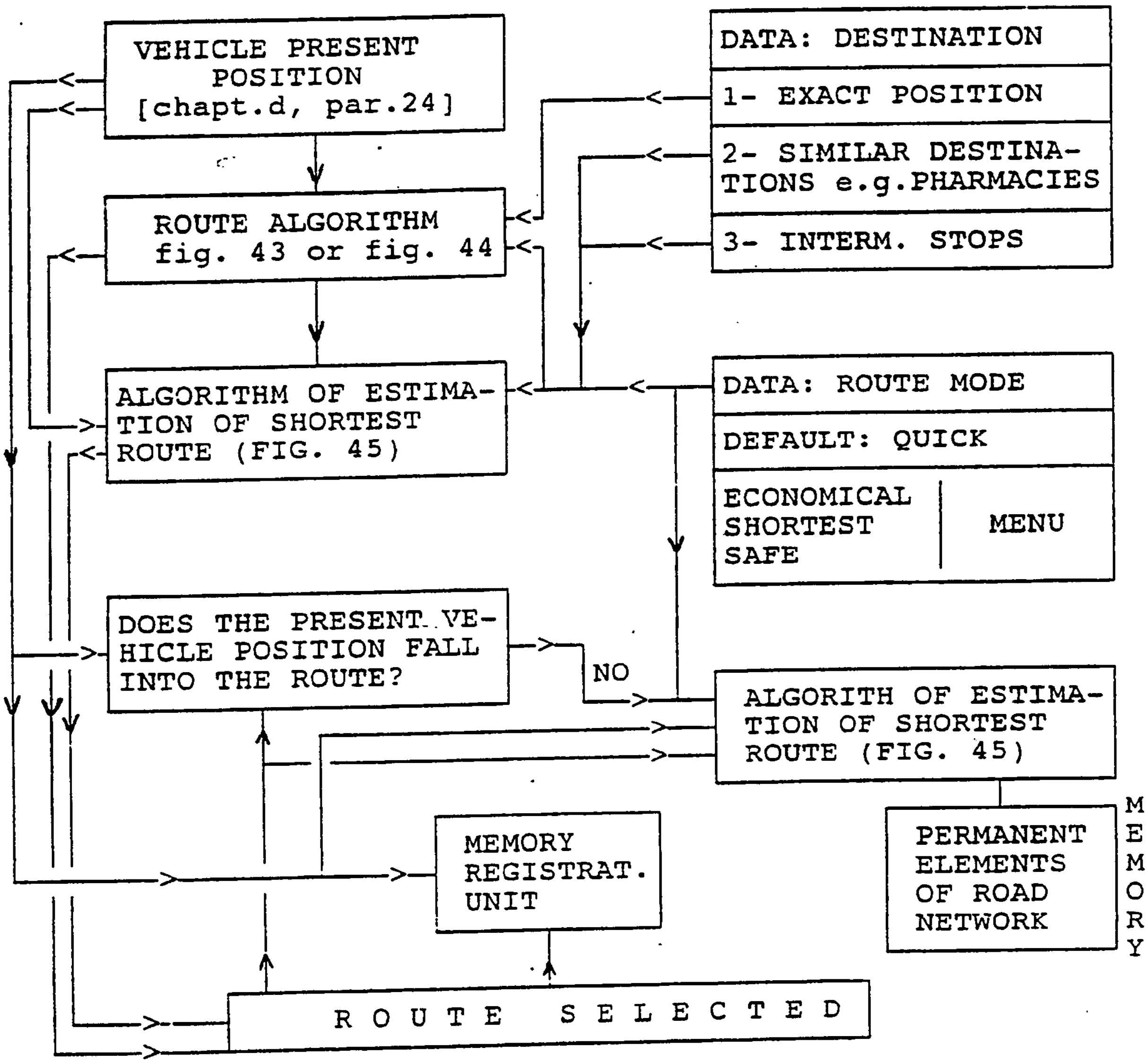

EUROPE
LEVEL A
(INTERNATIONAL EUROPEAN NETWORK)
SPAIN
ITALY
GREECE
GERMANY
LEVEL B
(INTERURBAN COUNTRY NETWORK)
PATRAS
ATHENS
THESSALONIKI
LEVEL C
(URBAN CITY NETWORK)
ILIOUPOLIS
TAVROS
PERISTERI
LEVEL D
(SUBURBAN DISTRICT NETWORK)
Zip Code 17733
17734
17735
LEVEL E
(SUBURBAN NETWORK)

FIGURE 47



VEHICLE PRESENT POSITION [chapt.d, par.24]
ROUTE ALGORITHM fig. 43 or fig. 44
ALGORITHM OF ESTIMATION OF SHORTEST ROUTE (FIG. 45)
DOES THE PRESENT VEHICLE POSITION FALL INTO THE ROUTE?
NO
MEMORY REGISTRAT. UNIT
ROUTE SELECTED
DATA: DESTINATION
1- EXACT POSITION
2- SIMILAR DESTINATIONS e.g.PHARMACIES
3- INTERM. STOPS
DATA: ROUTE MODE
DEFAULT: QUICK
ECONOMICAL
SHORTEST
SAFE
MENU
ALGORITH OF ESTIMATION OF SHORTEST ROUTE (FIG. 45)
PERMANENT ELEMENTS OF ROAD NETWORK
MEMORY

FIGURE 48

$$\varphi_2 = \varphi_1 - l_2/\rho_2$$
$$x_2 = x_1 + \rho_1(\sin\varphi_1 - \sin\varphi_2)$$
$$y_2 = y_1 - \rho_1(\cos\varphi_1 - \cos\varphi_2)$$

$$\varphi_1 = \varphi_0 - l_1/\rho_1$$
$$x_1 = x_0 + \rho_1(\sin\varphi_0 - \sin\varphi_1)$$
$$y_1 = y_0 - \rho_1(\cos\varphi_0 - \cos\varphi_1)$$

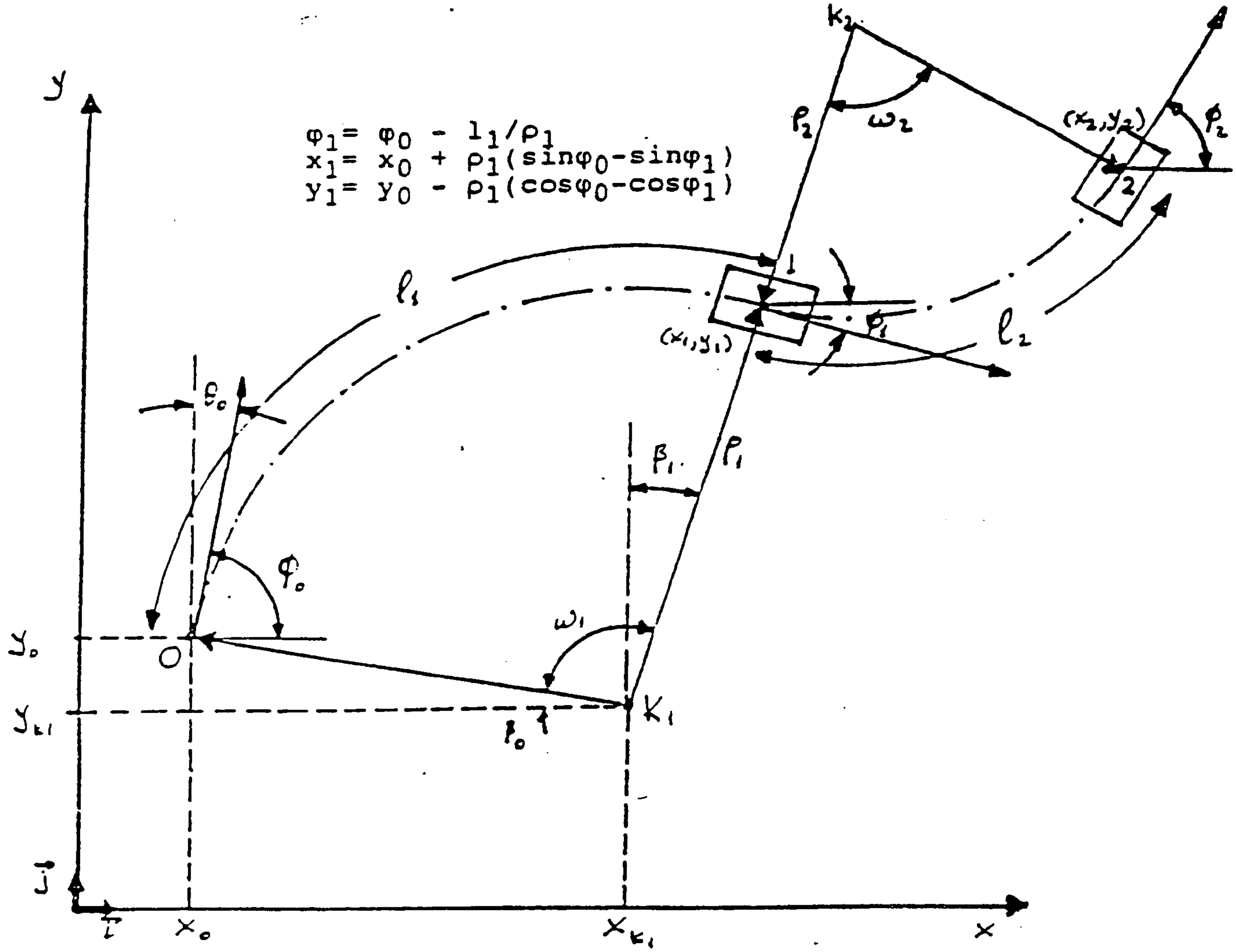


FIGURE 49

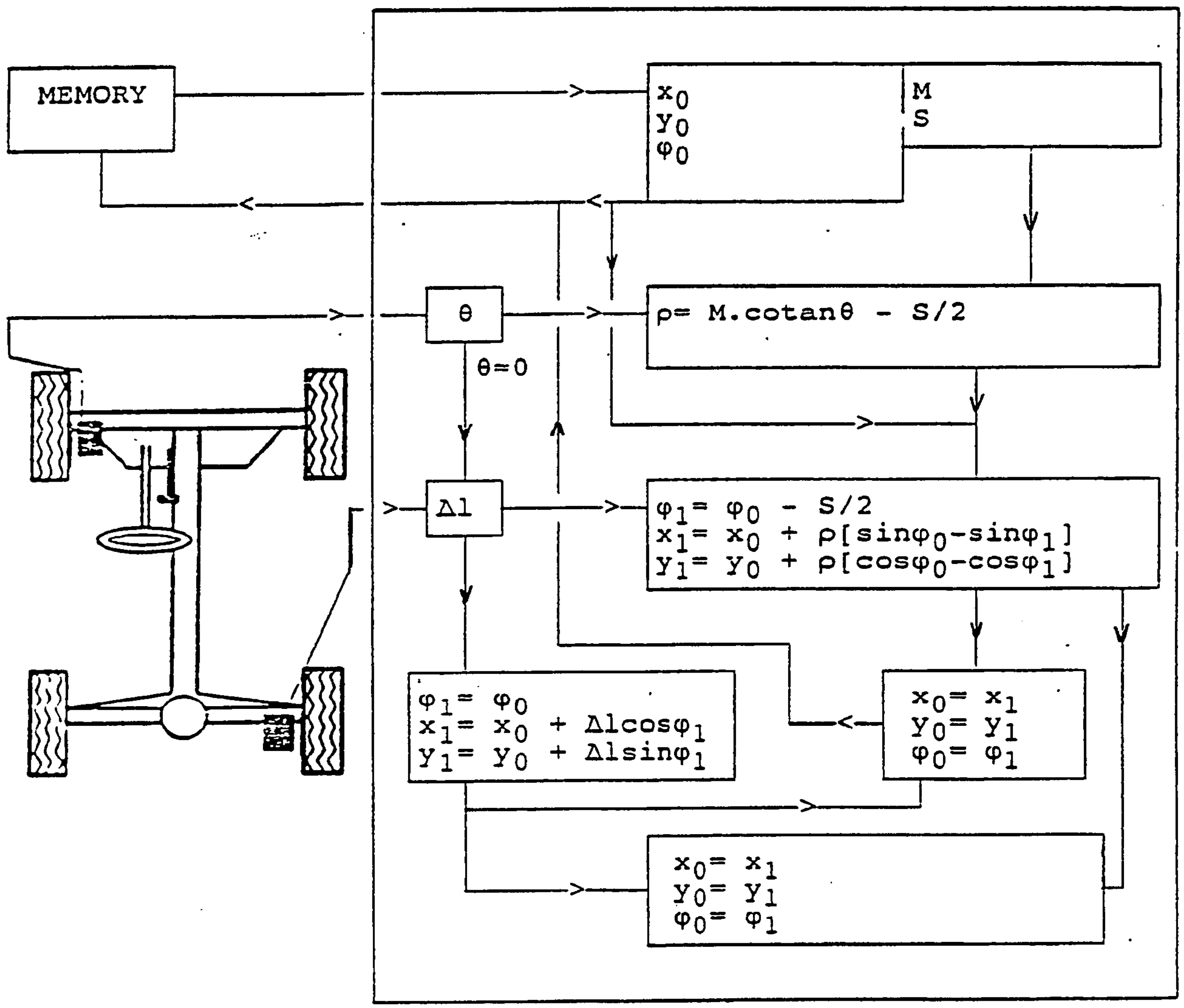

MEMORY
x0
y0
φ0
M
S
θ
ρ= M.cotanθ - S/2
θ=0
Δl
φ1= φ0 - S/2
x1= x0 + ρ[sinφ0-sinφ1]
y1= y0 + ρ[cosφ0-cosφ1]
φ1= φ0
x1= x0 + Δlcosφ1
y1= y0 + Δlsinφ1
x0= x1
y0= y1
φ0= φ1
x0= x1
y0= y1
φ0= φ1

FIGURE 50

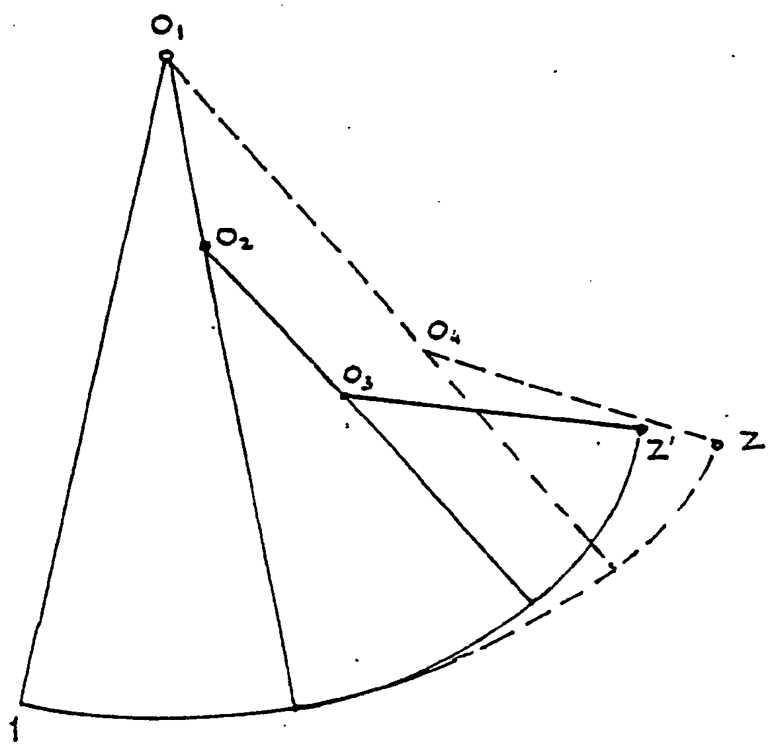


FIGURE 51

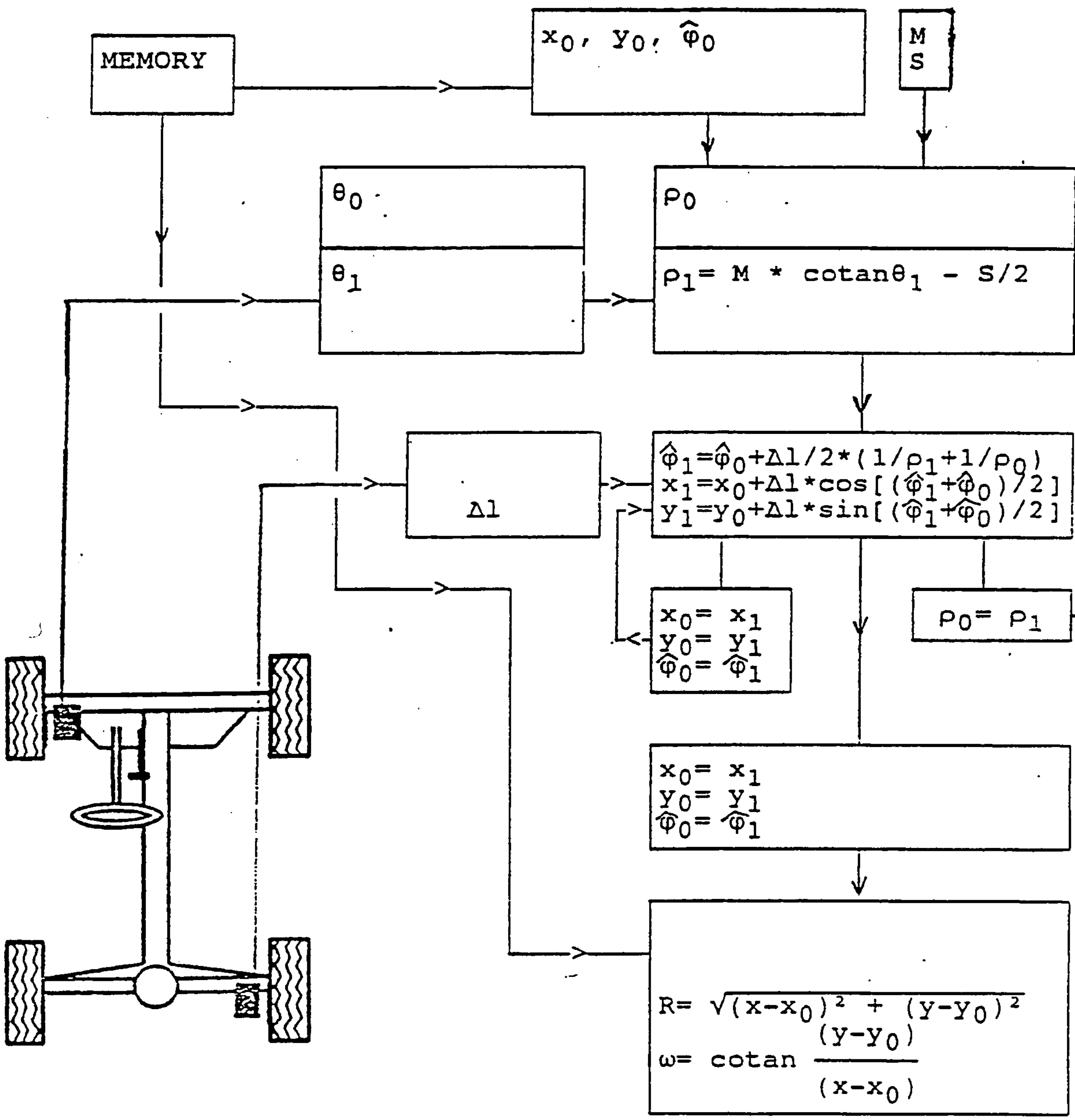

MEMORY
$x_0, y_0, \hat{\varphi}_0$
M
S
θ_0
θ_1
ρ_0
$\rho_1 = M * \cot\theta_1 - S/2$
Δl
$\hat{\varphi}_1 = \hat{\varphi}_0 + \Delta l/2 * (1/\rho_1 + 1/\rho_0)$
$x_1 = x_0 + \Delta l * \cos[(\hat{\varphi}_1 + \hat{\varphi}_0)/2]$
$y_1 = y_0 + \Delta l * \sin[(\hat{\varphi}_1 + \hat{\varphi}_0)/2]$
$x_0 = x_1$
$y_0 = y_1$
$\hat{\varphi}_0 = \hat{\varphi}_1$
$\rho_0 = \rho_1$
$x_0 = x_1$
$y_0 = y_1$
$\hat{\varphi}_0 = \hat{\varphi}_1$
$R = \sqrt{(x-x_0)^2 + (y-y_0)^2}$
$\omega = \cot \frac{(y-y_0)}{(x-x_0)}$

FIGURE 52

$$x_2 = x_1 + dl_{1-2}.\cos[(\varphi_2+\varphi_1)/2]$$
$$y_2 = y_1 + dl_{1-2}.\sin[(\varphi_2+\varphi_1)/2]$$

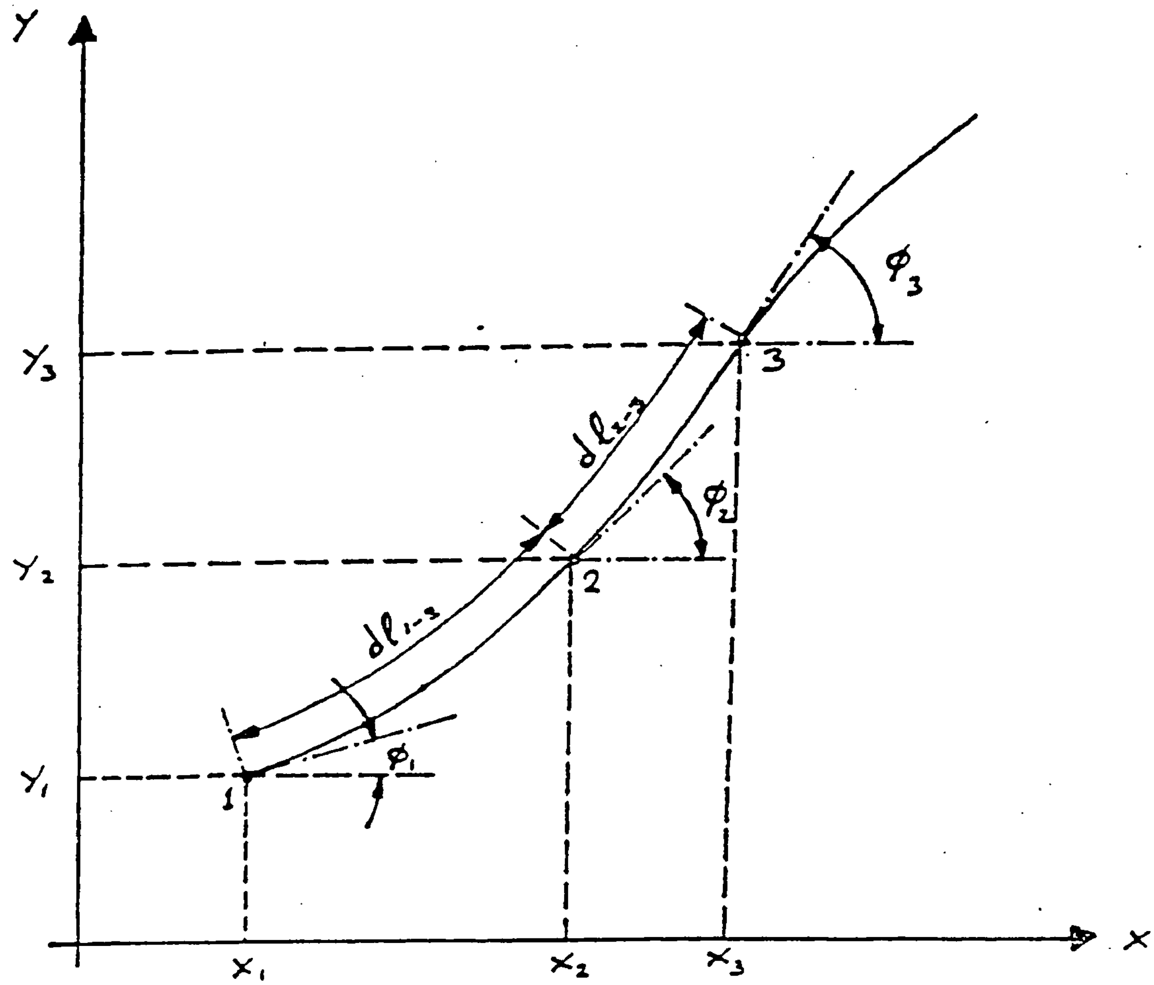


FIGURE 53

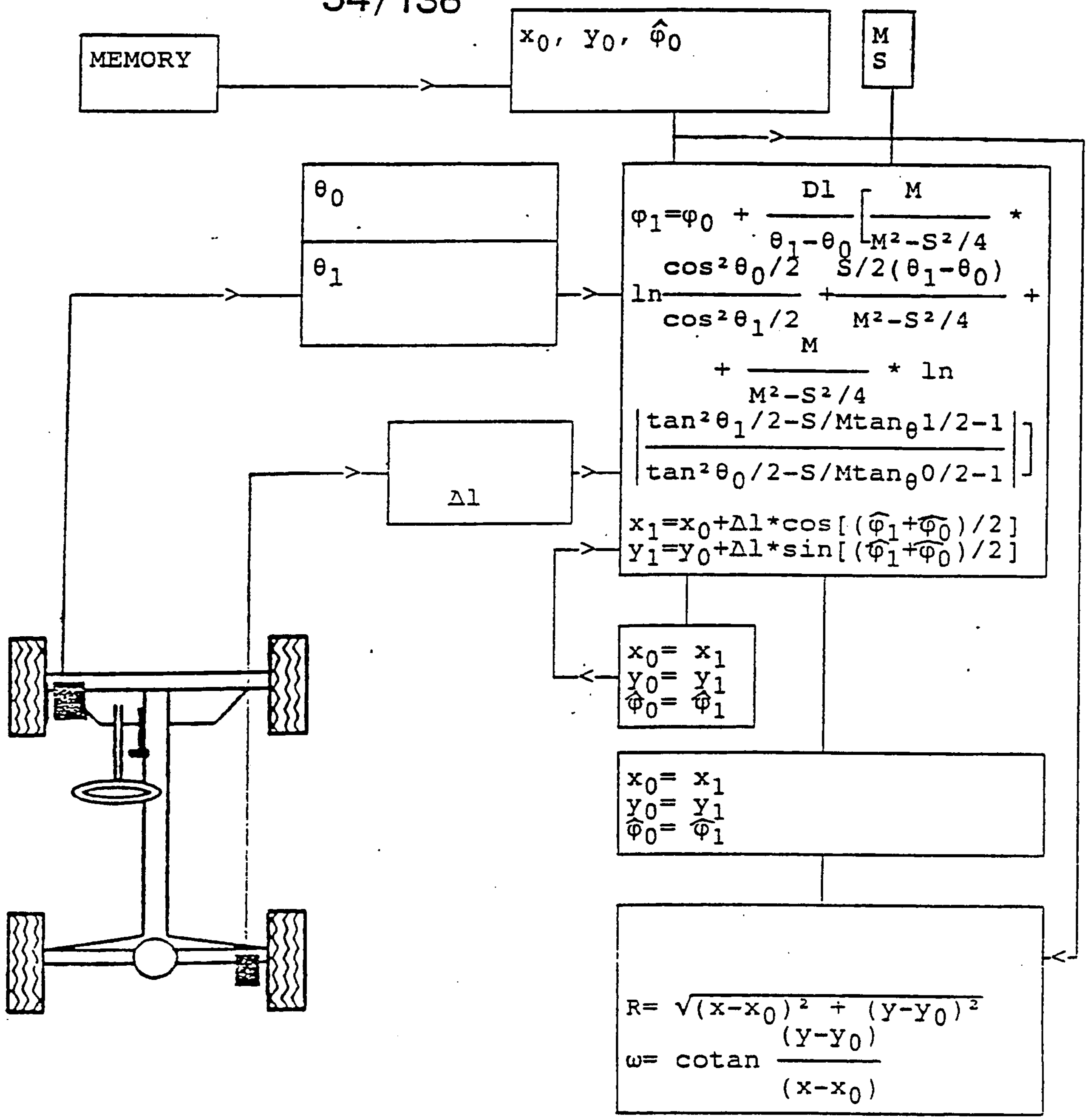

MEMORY
x0, y0, φ̂0
M
S
θ0
θ1
Δl
φ1=φ0 + Dl/(θ1-θ0) [M/(M²-S²/4) * ln (cos²θ0/2)/(cos²θ1/2) + S/2(θ1-θ0)/(M²-S²/4) + + M/(M²-S²/4) * ln |(tan²θ1/2-S/Mtanθ1/2-1)/(tan²θ0/2-S/Mtanθ0/2-1)|]
x1=x0+Δl*cos[(φ̂1+φ̂0)/2]
y1=y0+Δl*sin[(φ̂1+φ̂0)/2]
x0= x1
y0= y1
φ̂0= φ̂1
x0= x1
y0= y1
φ̂0= φ̂1
R= √((x-x0)² + (y-y0)²)
ω= cotan (y-y0)/(x-x0)

FIGURE 54

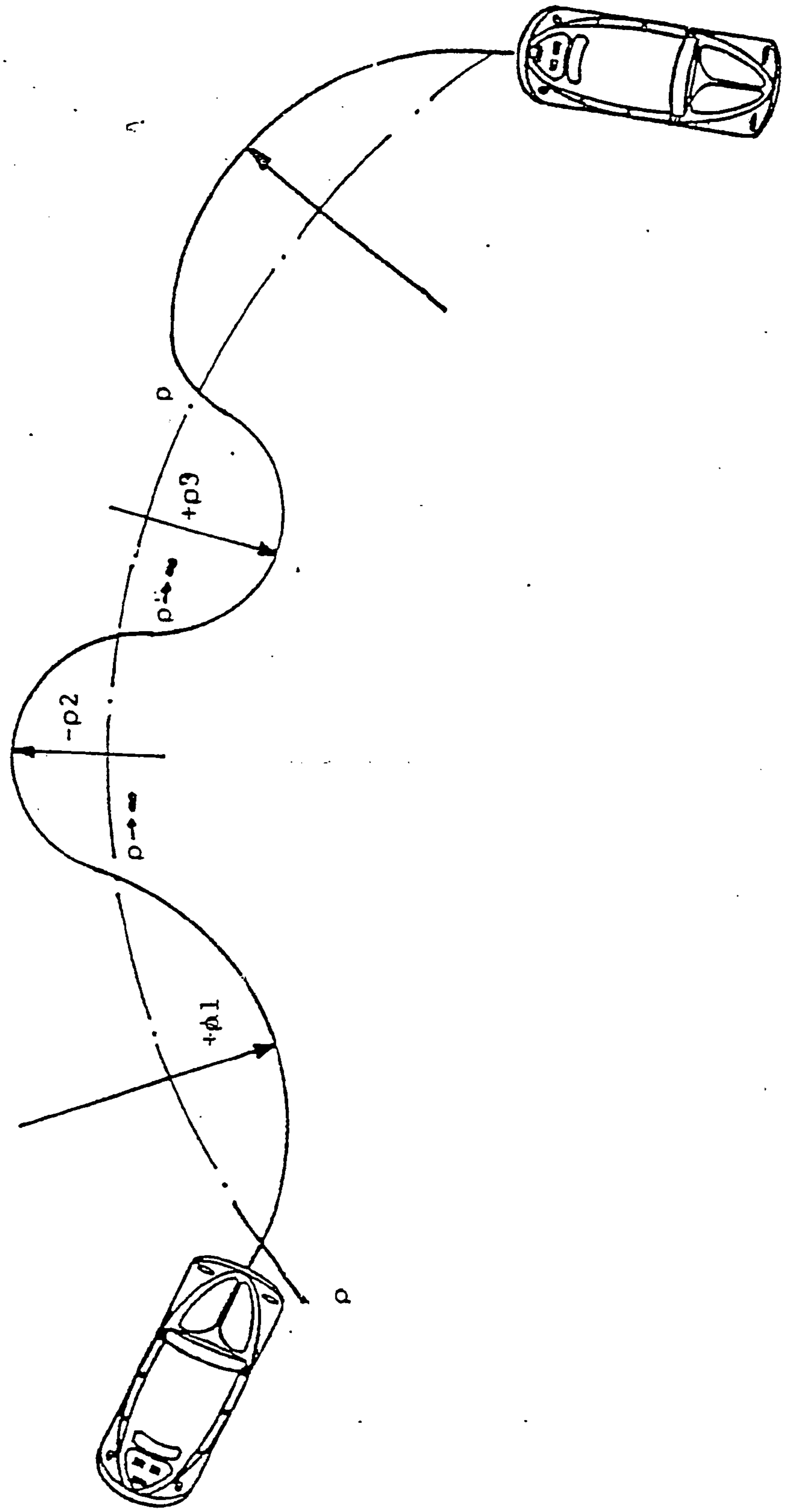
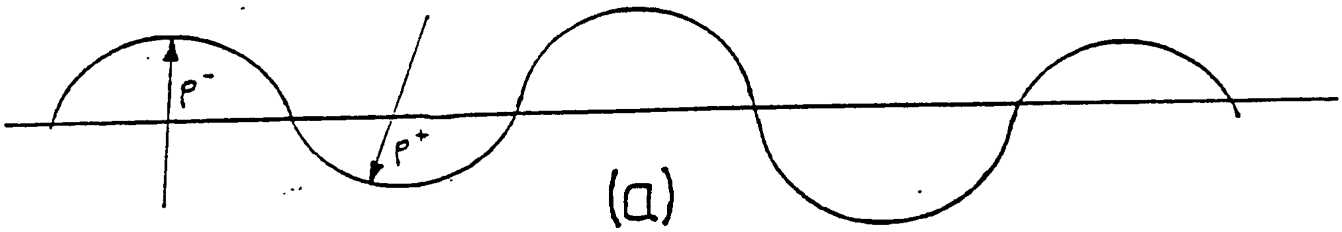
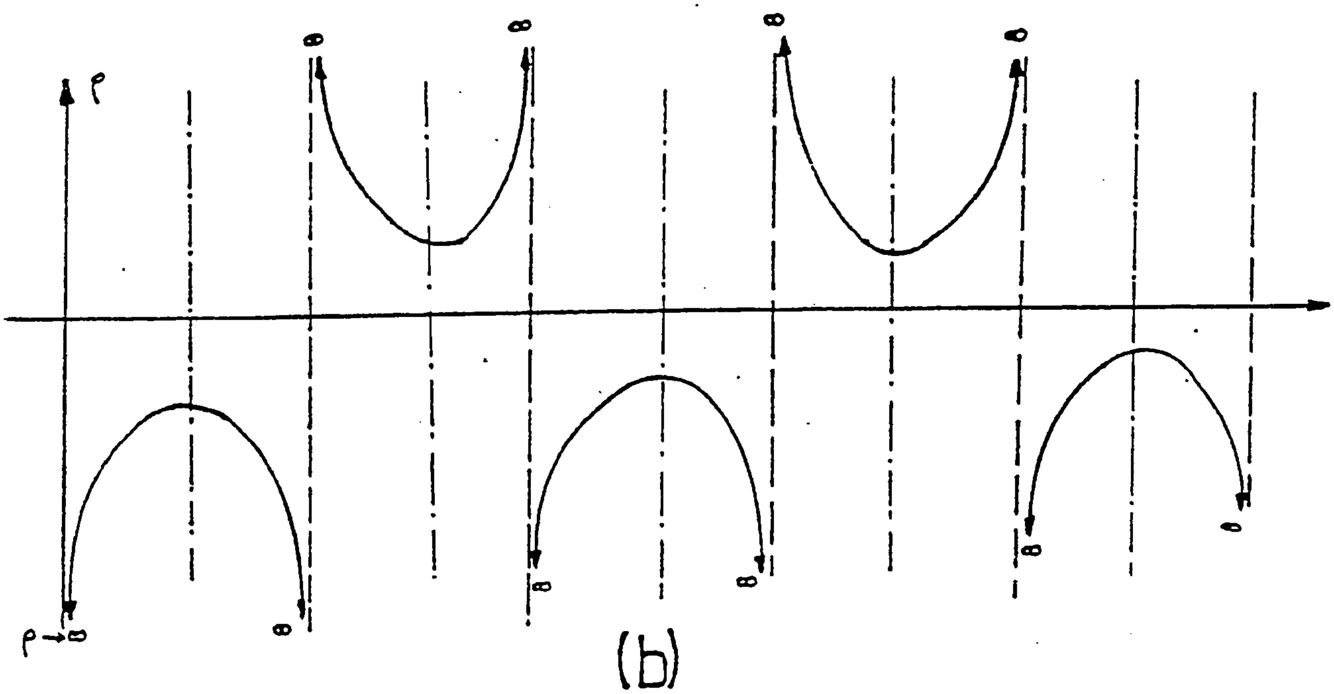


FIGURE 55

VEHICLE COURSE



ϱ = radius of course curve



θ = wheel turn angle

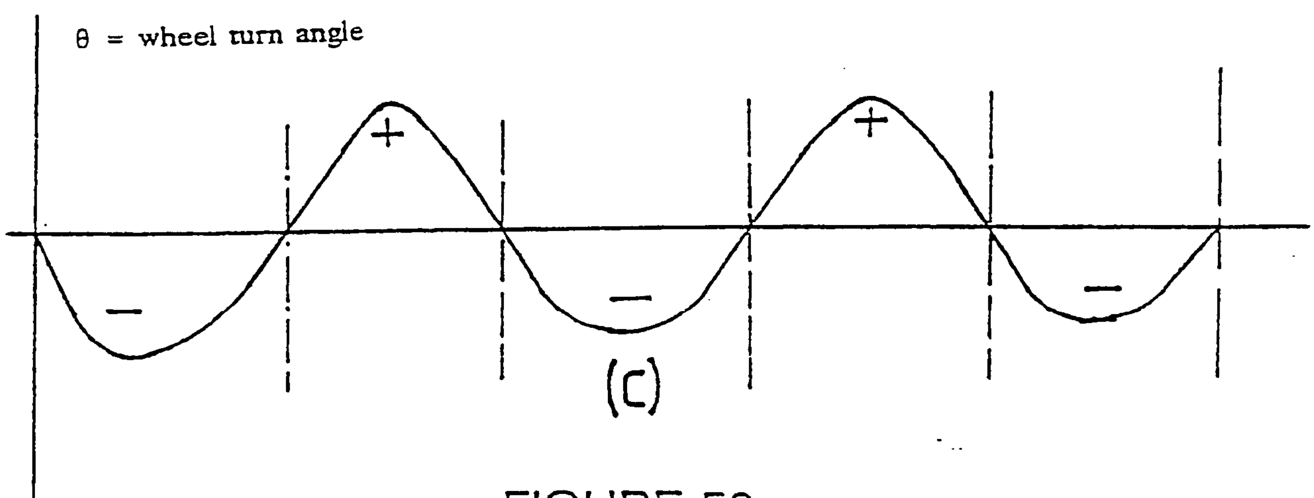
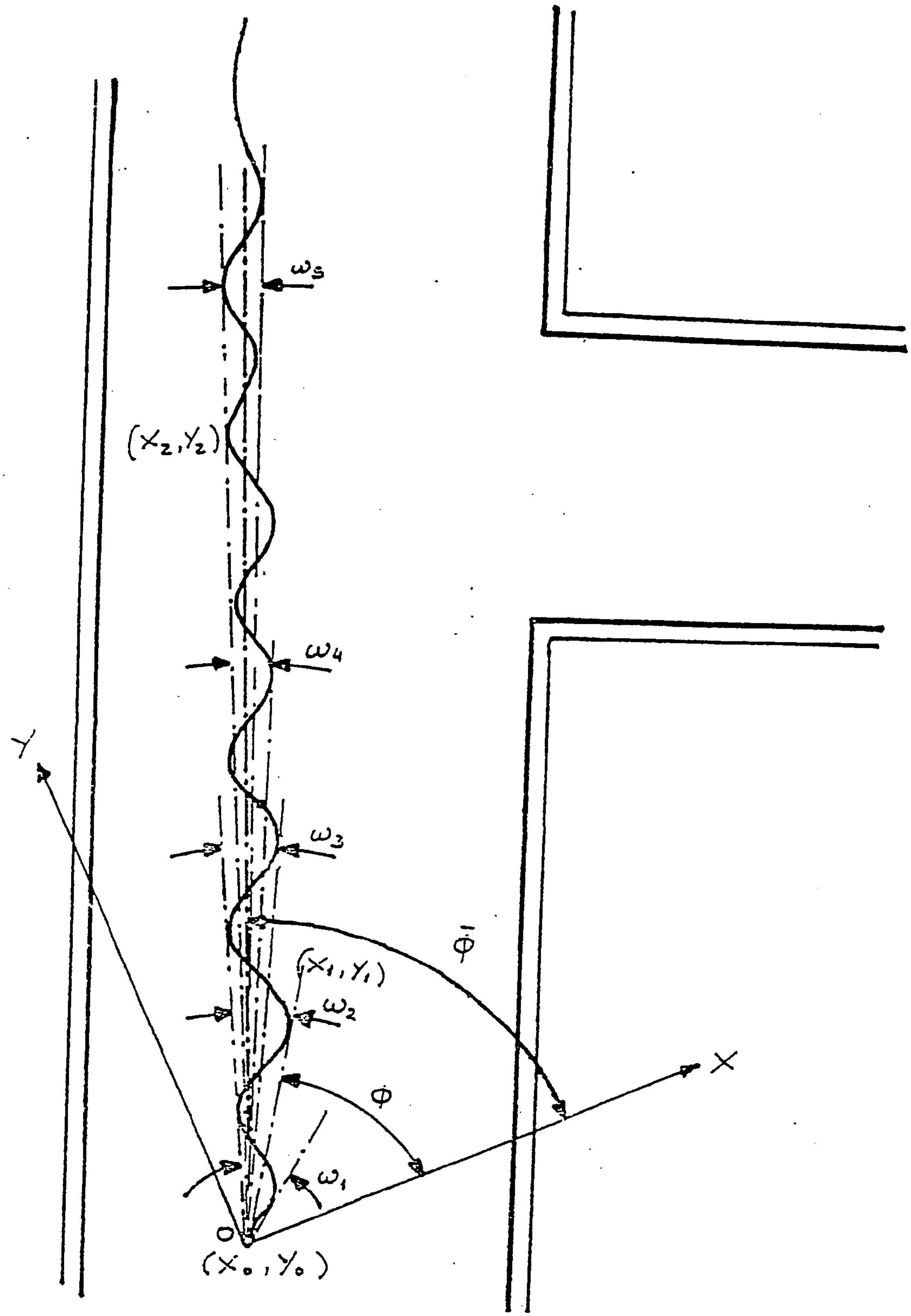


FIGURE 56



ω_5
(X_2, Y_2)
ω_4
Y
ω_3
$\bar{\phi}$
(X_1, Y_1)
ω_2
X
ϕ
ω_1
O
(X_0, Y_0)

FIGURE 57

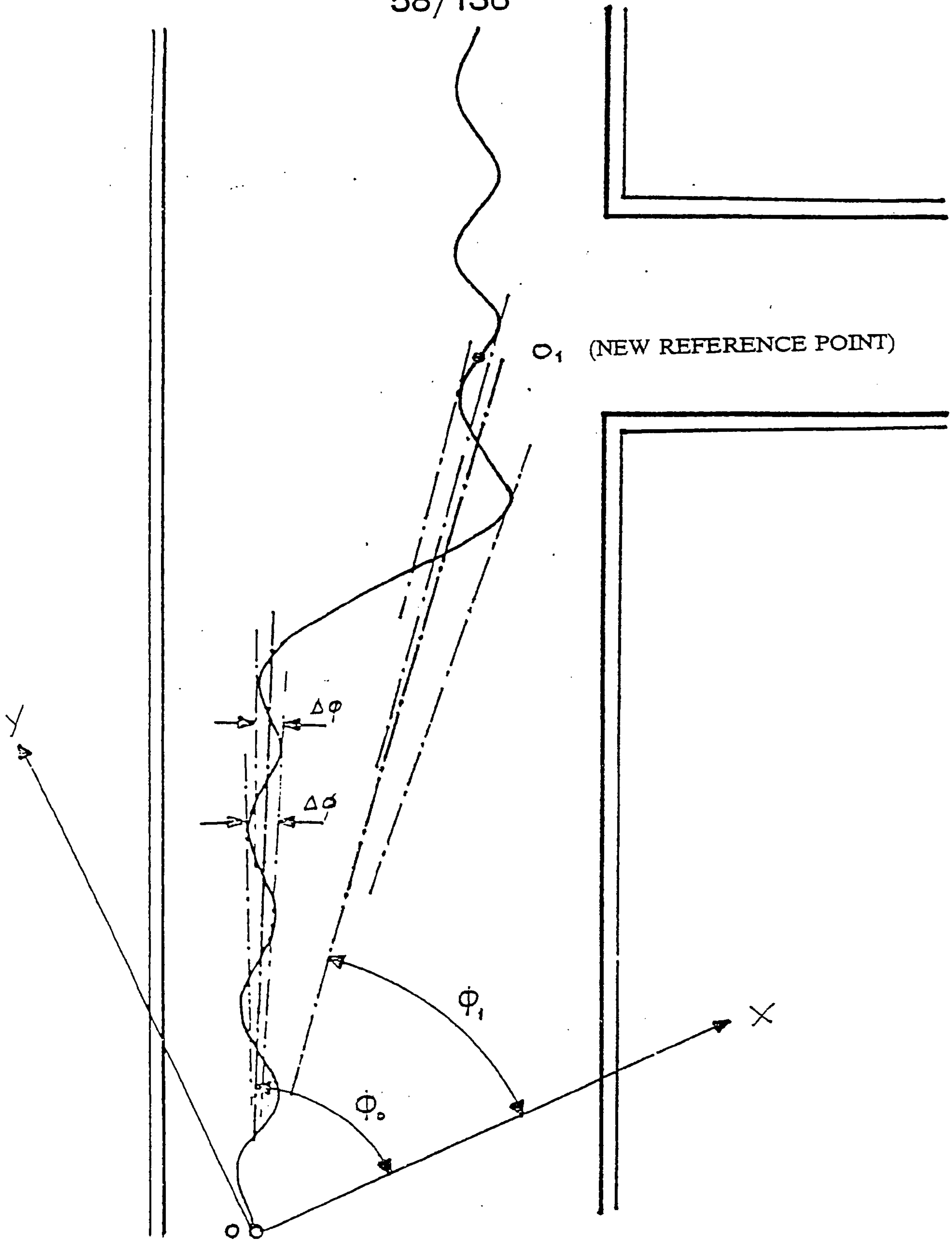


FIGURE 58

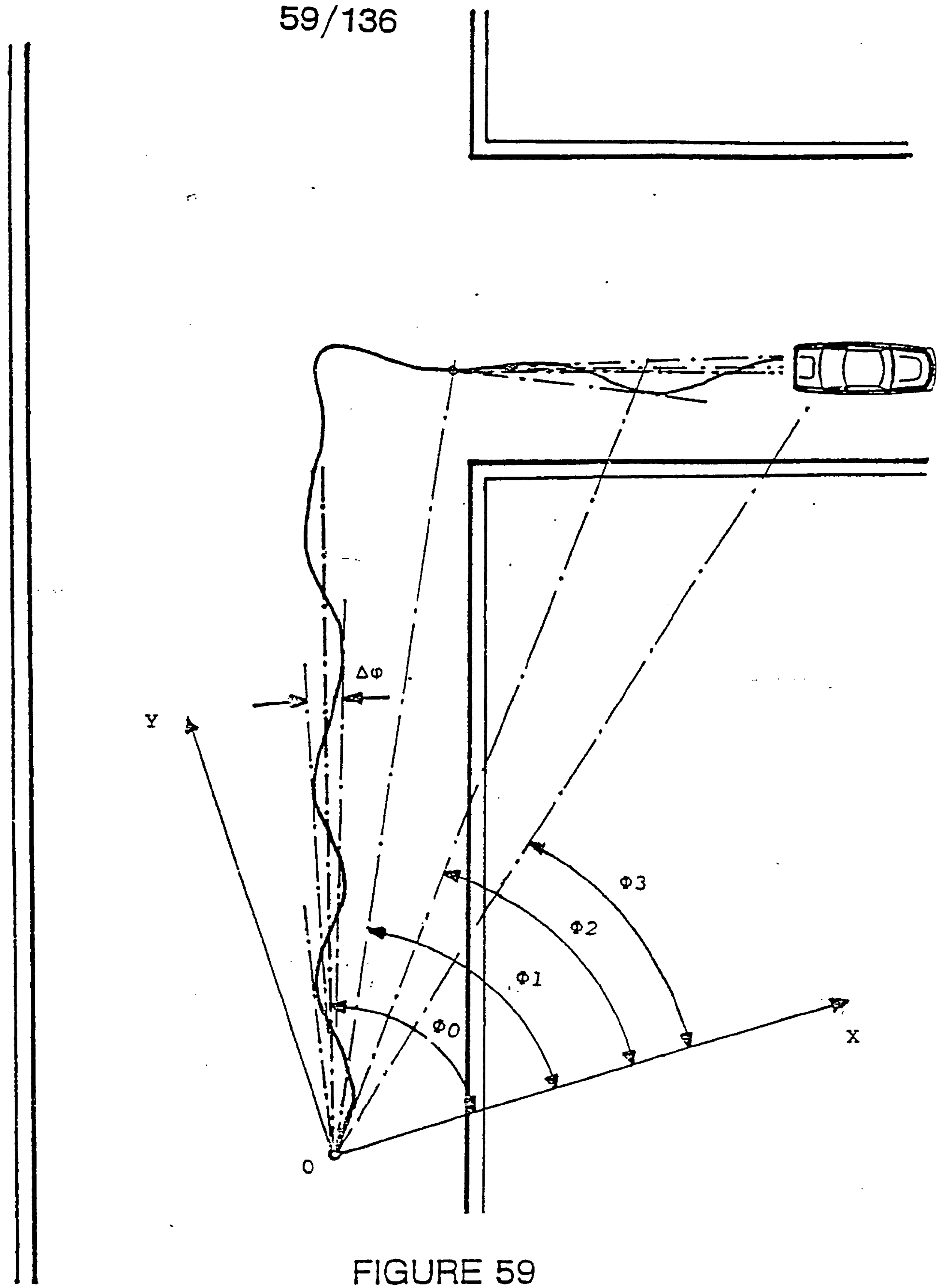


FIGURE 59

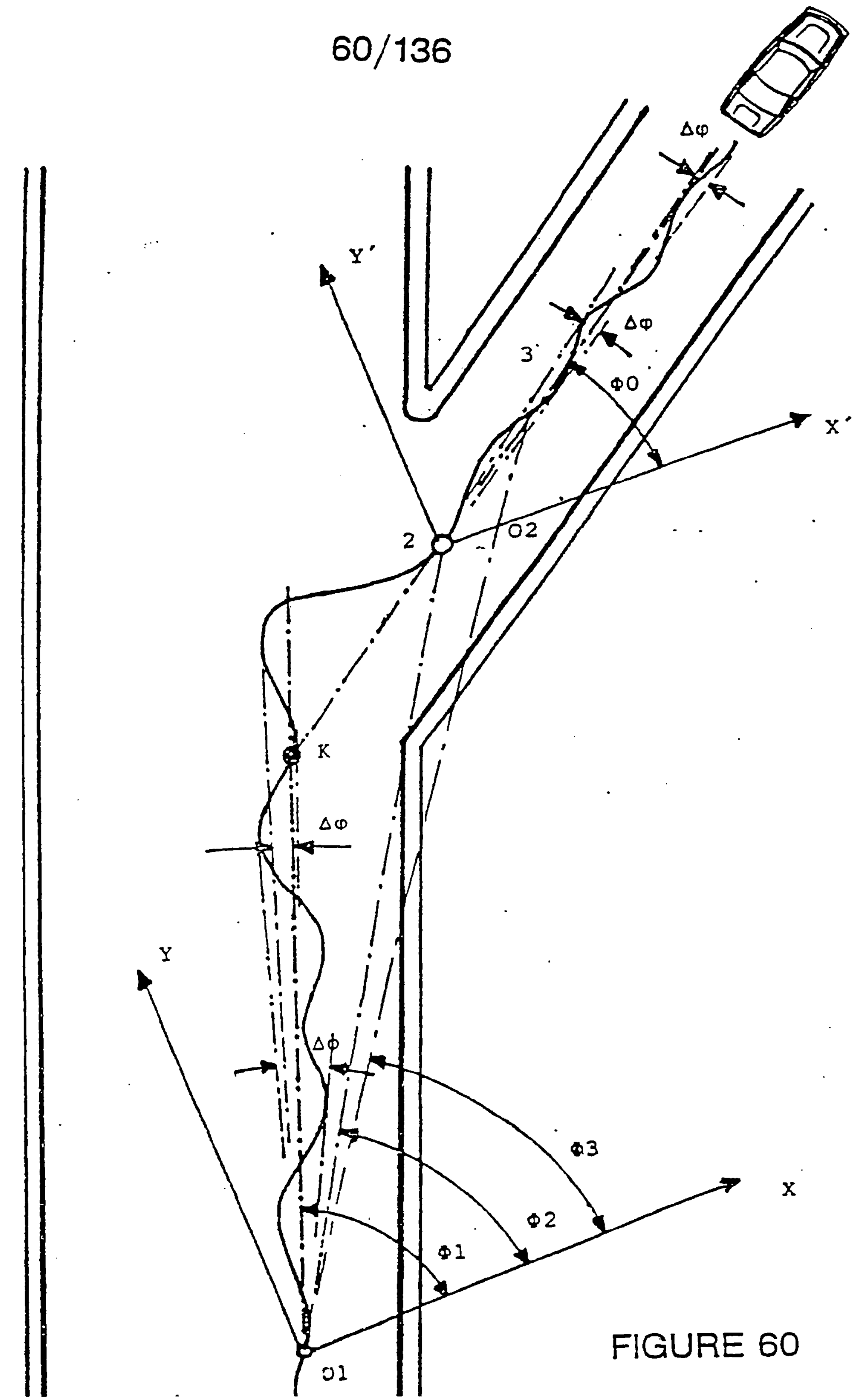
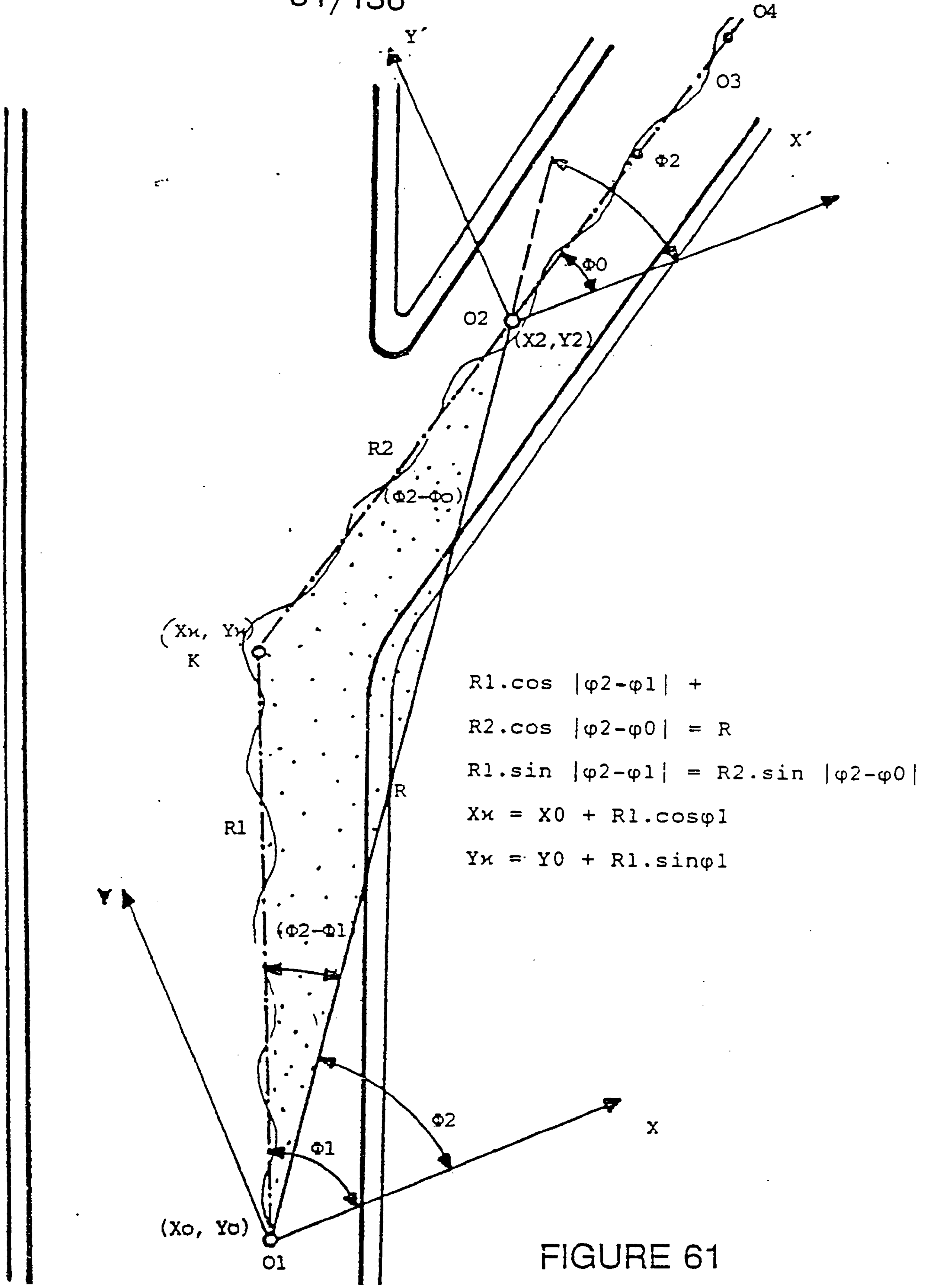


FIGURE 60



$$R1.\cos|\varphi2-\varphi1| +$$
$$R2.\cos|\varphi2-\varphi0| = R$$
$$R1.\sin|\varphi2-\varphi1| = R2.\sin|\varphi2-\varphi0|$$
$$X\kappa = X0 + R1.\cos\varphi1$$
$$Y\kappa = Y0 + R1.\sin\varphi1$$

FIGURE 61

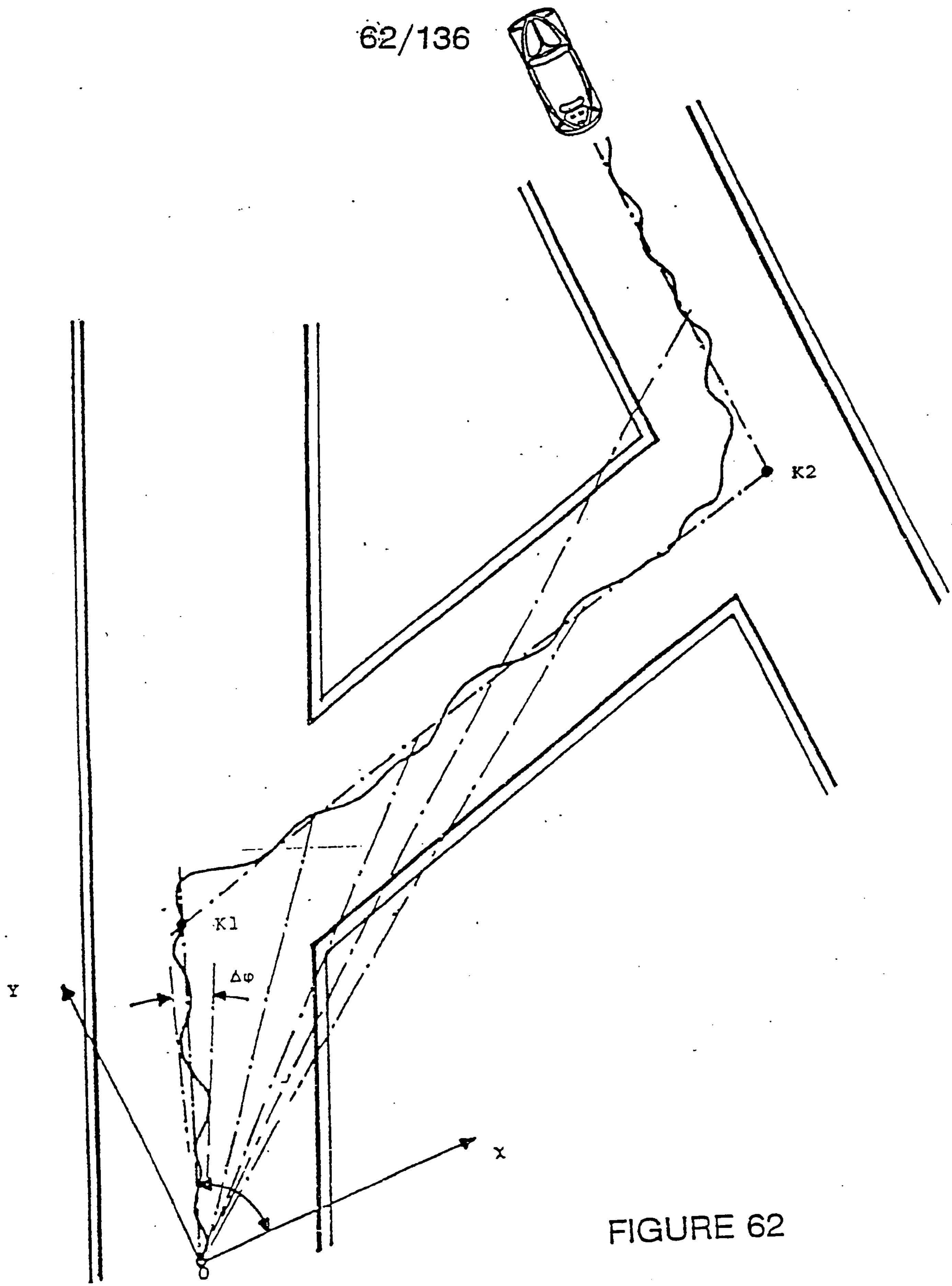


FIGURE 62

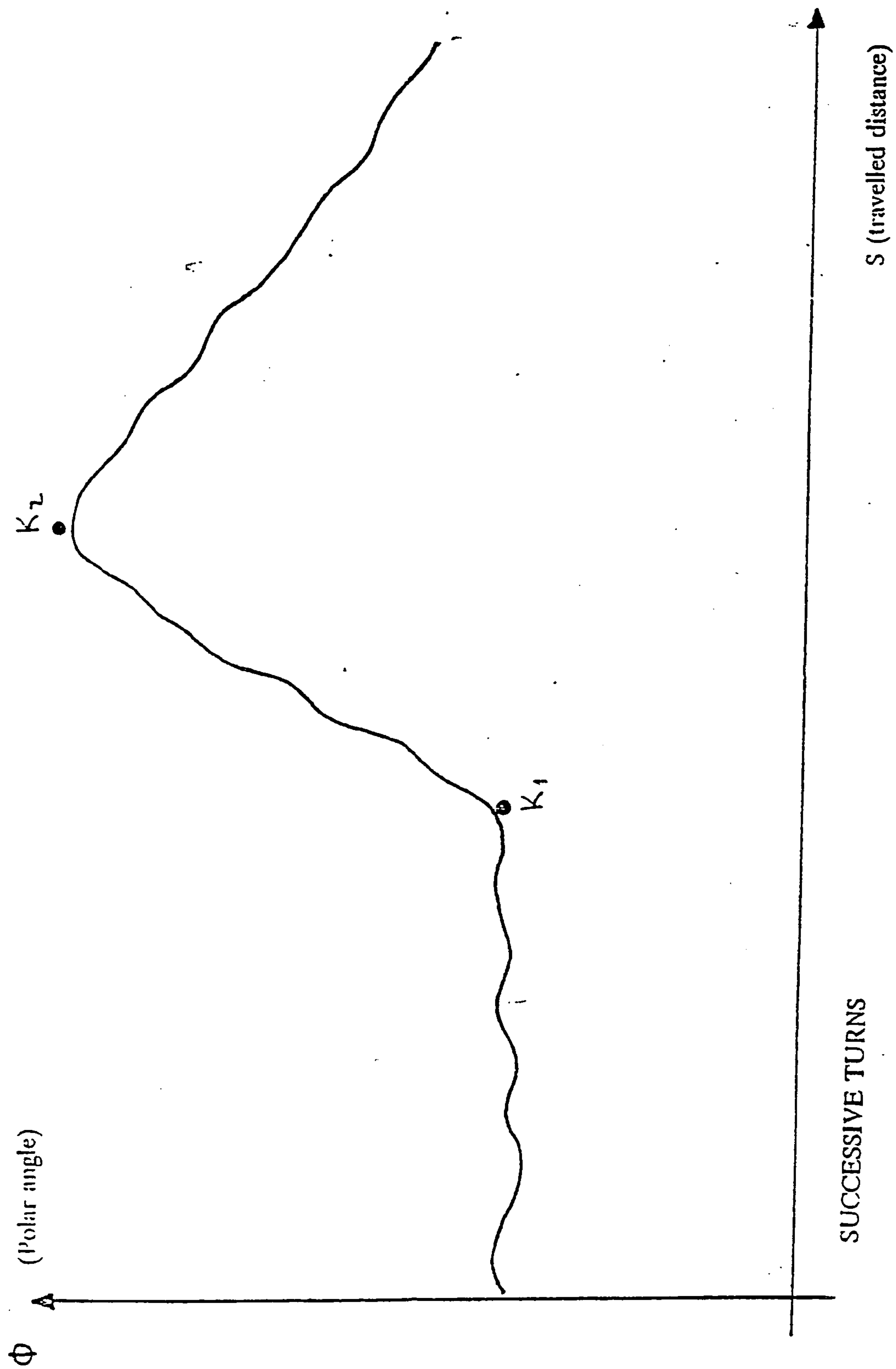


FIGURE 63

If $\exists k_0$ then $\omega(k_0+I) > \omega(k_0-I) + \Delta\omega, \quad \forall I = 1,2,3,...$

$R(j) = \sqrt{[x(k_0+I)-x(k_0)]^2 + [y(k_0+I)-y(k_0)]^2}$

$\Omega(j) = \text{cotan}[(y(k_0+I)-y(k_0))/(x(k_0+I)-x(k_0))]$

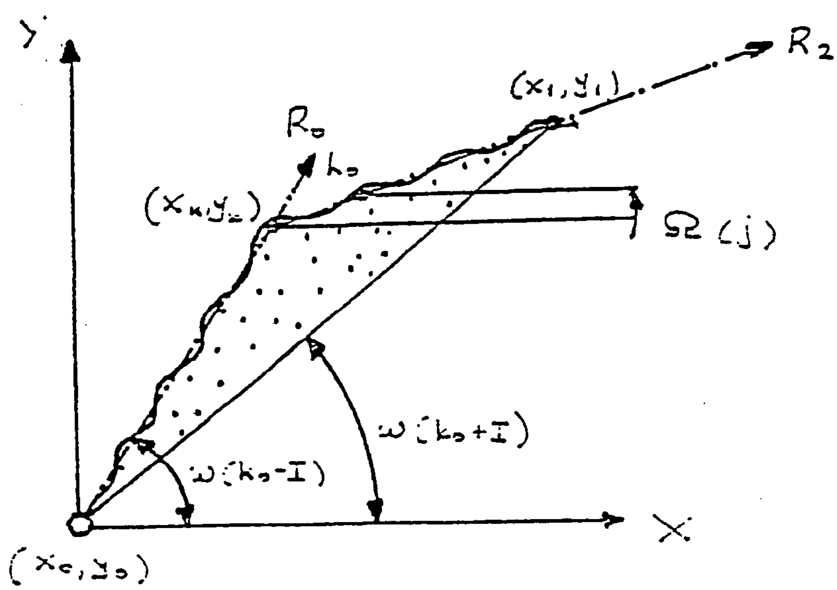
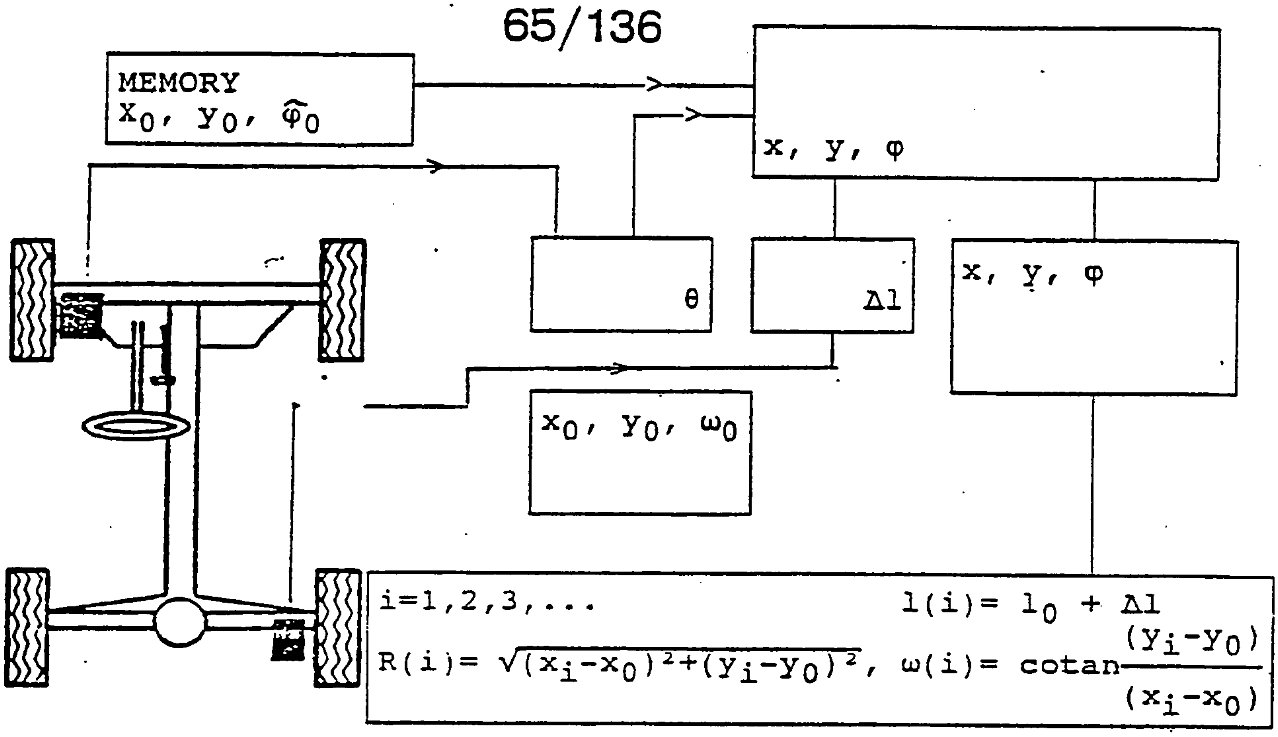


FIGURE 64



If	$\max[\omega(i)-\omega(j)] < \Delta\omega$ (Defined), Straight normal route
If	$\max[\omega(i)-\omega(j)] > \Delta\omega$ (Defined), -"- dangerous -"-
If	$\exists$ k_0 so $\omega(k_i) > \omega(i) + \Delta\omega$, $\forall\, k_i > k_0$ and $i < k_0$, performance of turn
If	$\exists$ k_0 so $\omega(k_i) > \omega(i) + \Delta\omega$, $\forall\, k_0 < k_i < k_1$ and $k_1-k_0 < 5$, and $\omega(k_1+I) < \omega(k_i)$, change of lane
If	$\exists$ k_0, k_1 so $\omega(k_0+I) > \omega(k_0-I) + \Delta\omega$ Λ $\omega(k_1+I) < \omega(k_0+I)$ Λ $k_1-k_0 >$ road width, successive turns

Fig. 64 continued ....

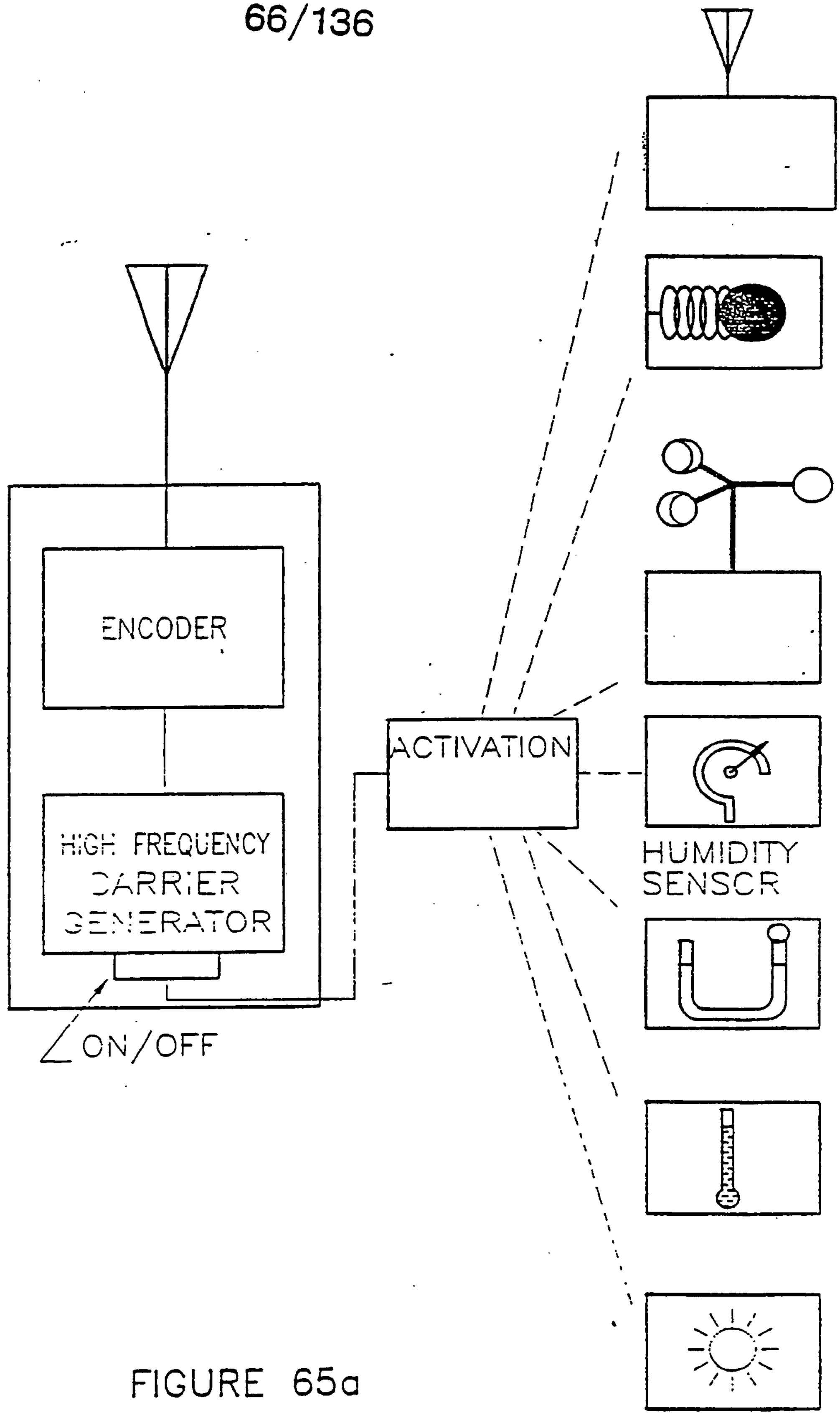

ENCODER
HIGH FREQUENCY CARRIER GENERATOR
ON/OFF
ACTIVATION
HUMIDITY SENSOR

FIGURE 65a

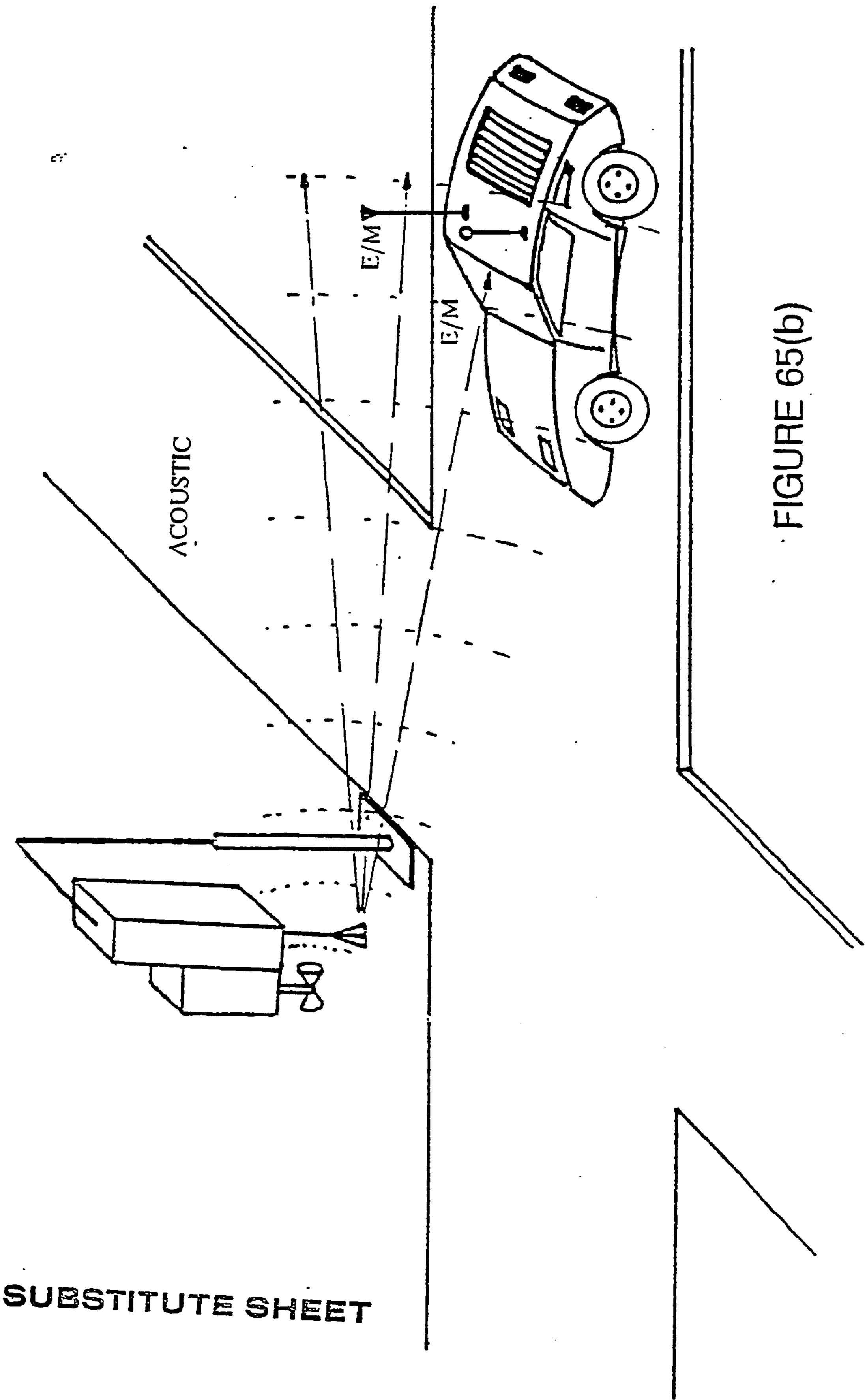


FIGURE 65(b)

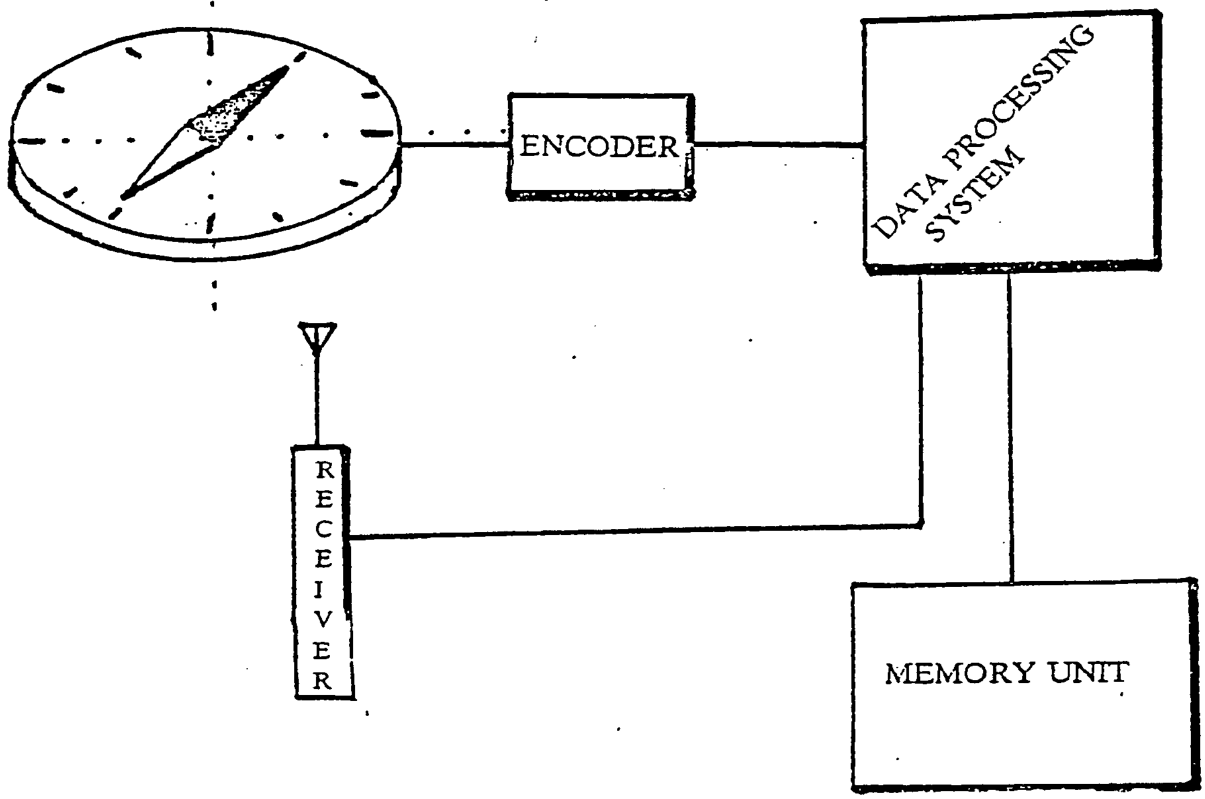


FIGURE 66

KA: TRANSMITTER CODE

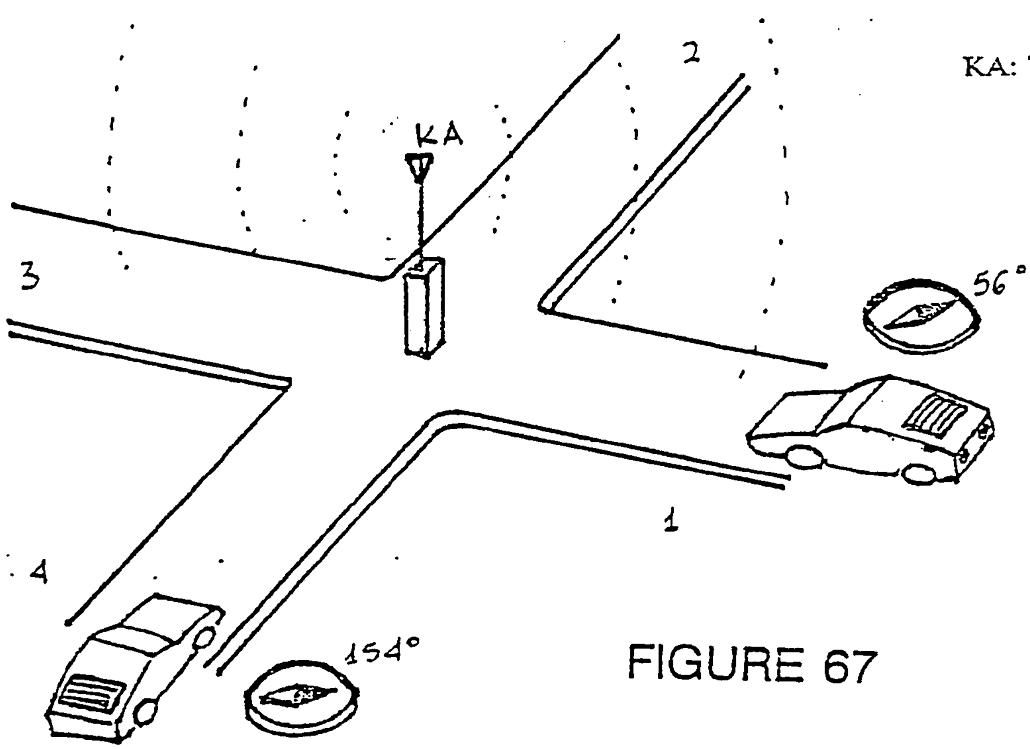


FIGURE 67

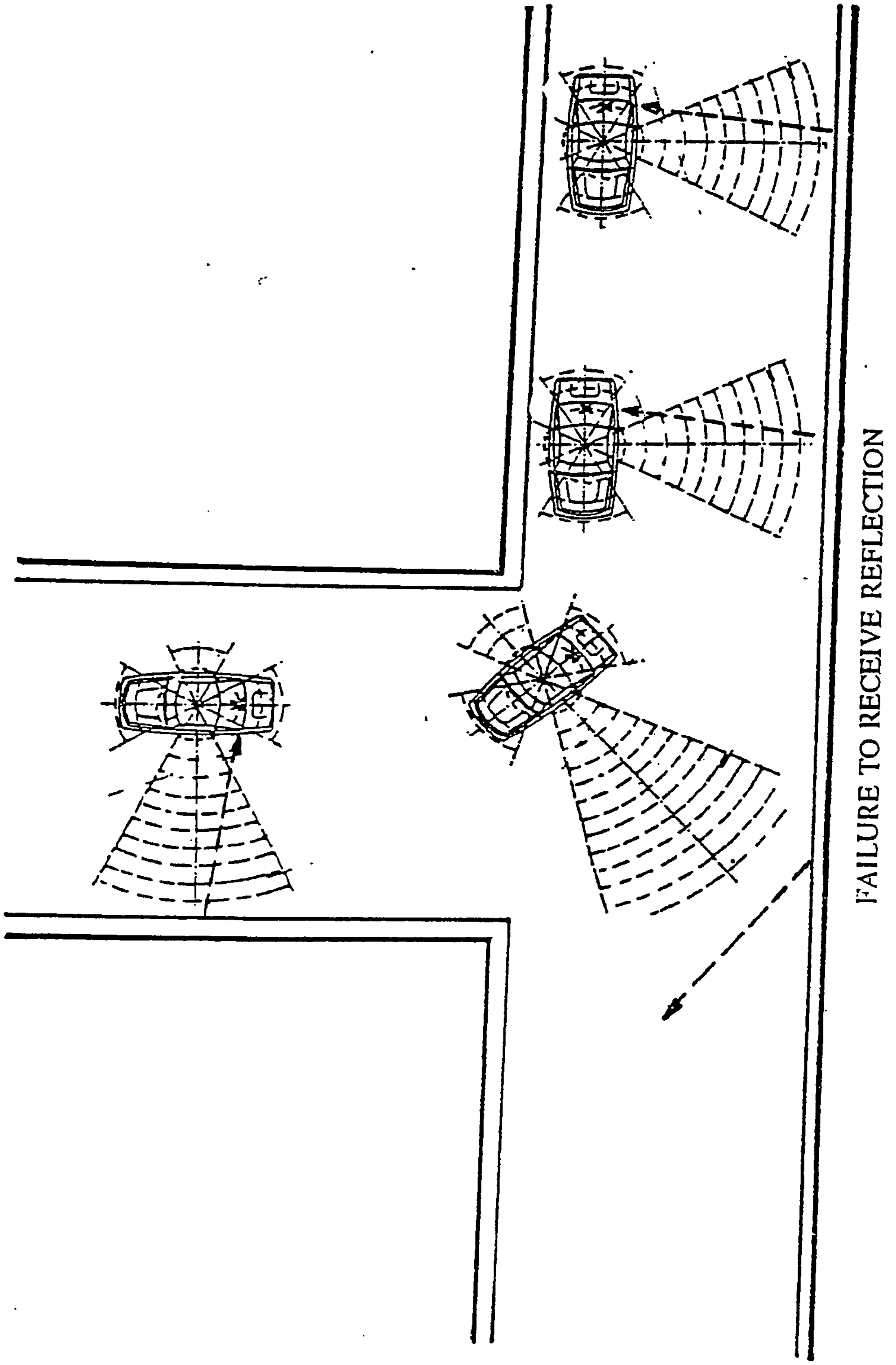


FIGURE 68

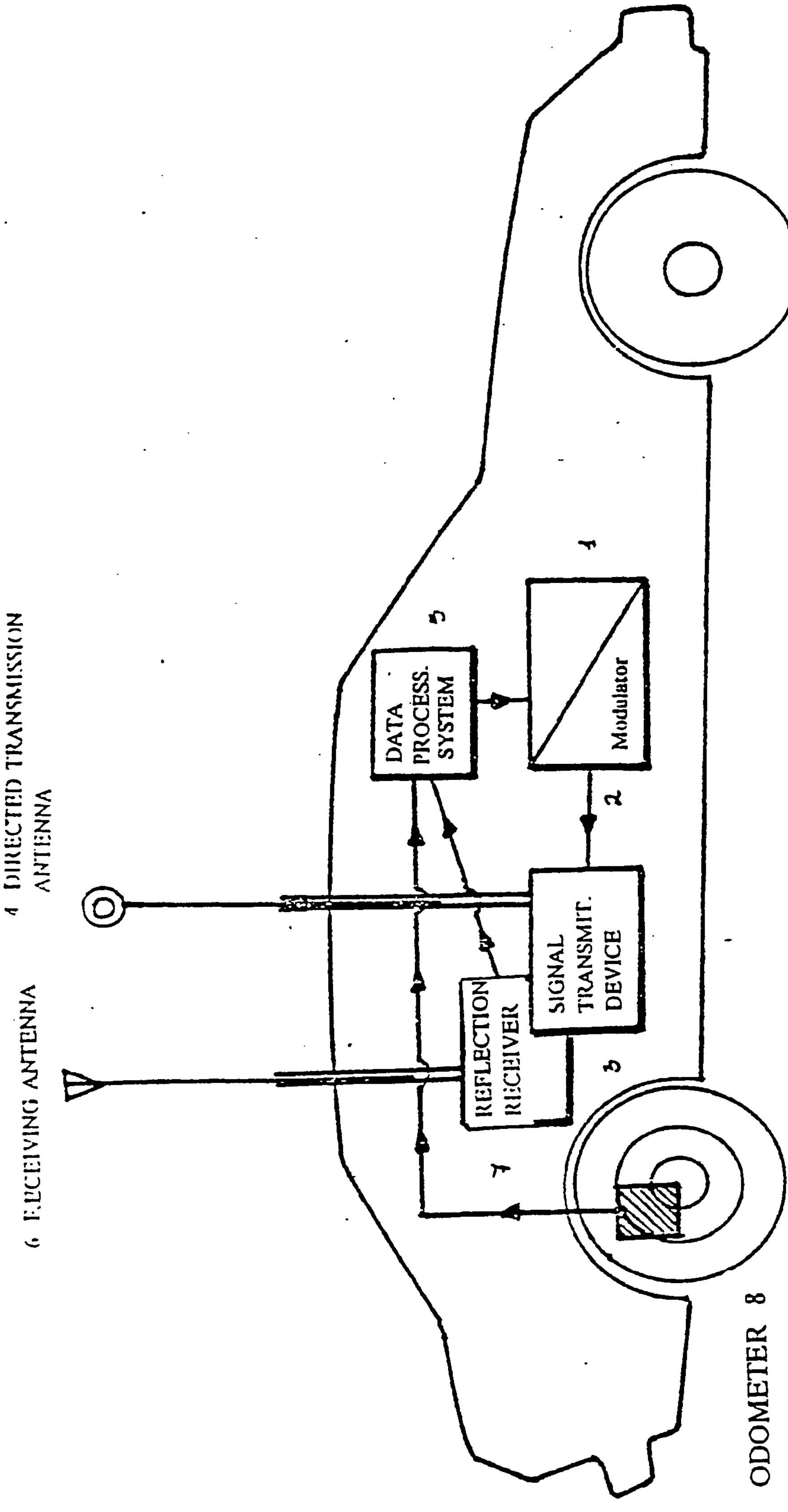

6 RECEIVING ANTENNA
4 DIRECTED TRANSMISSION ANTENNA
DATA PROCESS. SYSTEM
Modulator
SIGNAL TRANSMIT. DEVICE
REFLECTION RECEIVER
ODOMETER 8

FIGURE 69

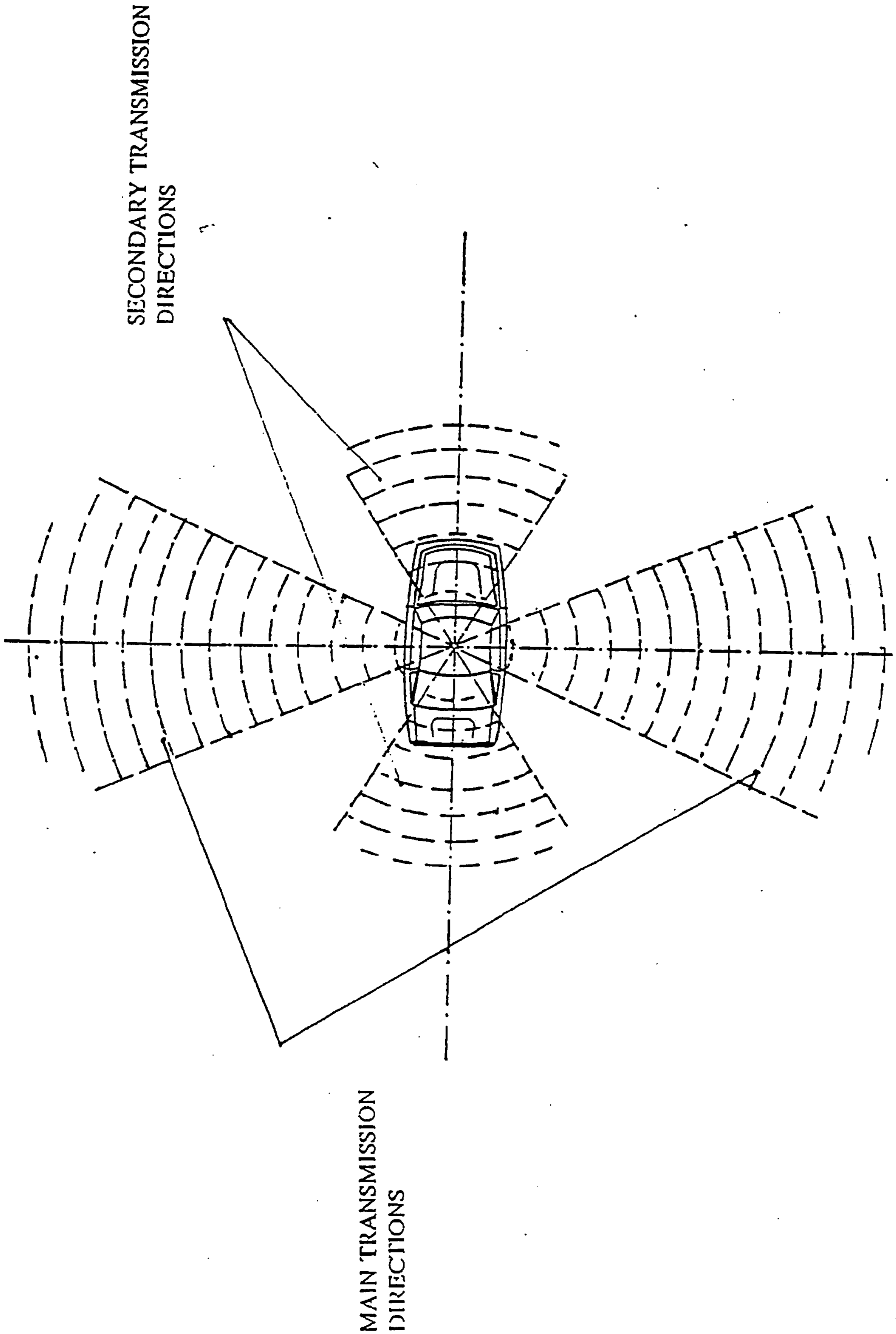

SECONDARY TRANSMISSION DIRECTIONS
MAIN TRANSMISSION DIRECTIONS

FIGURE 70

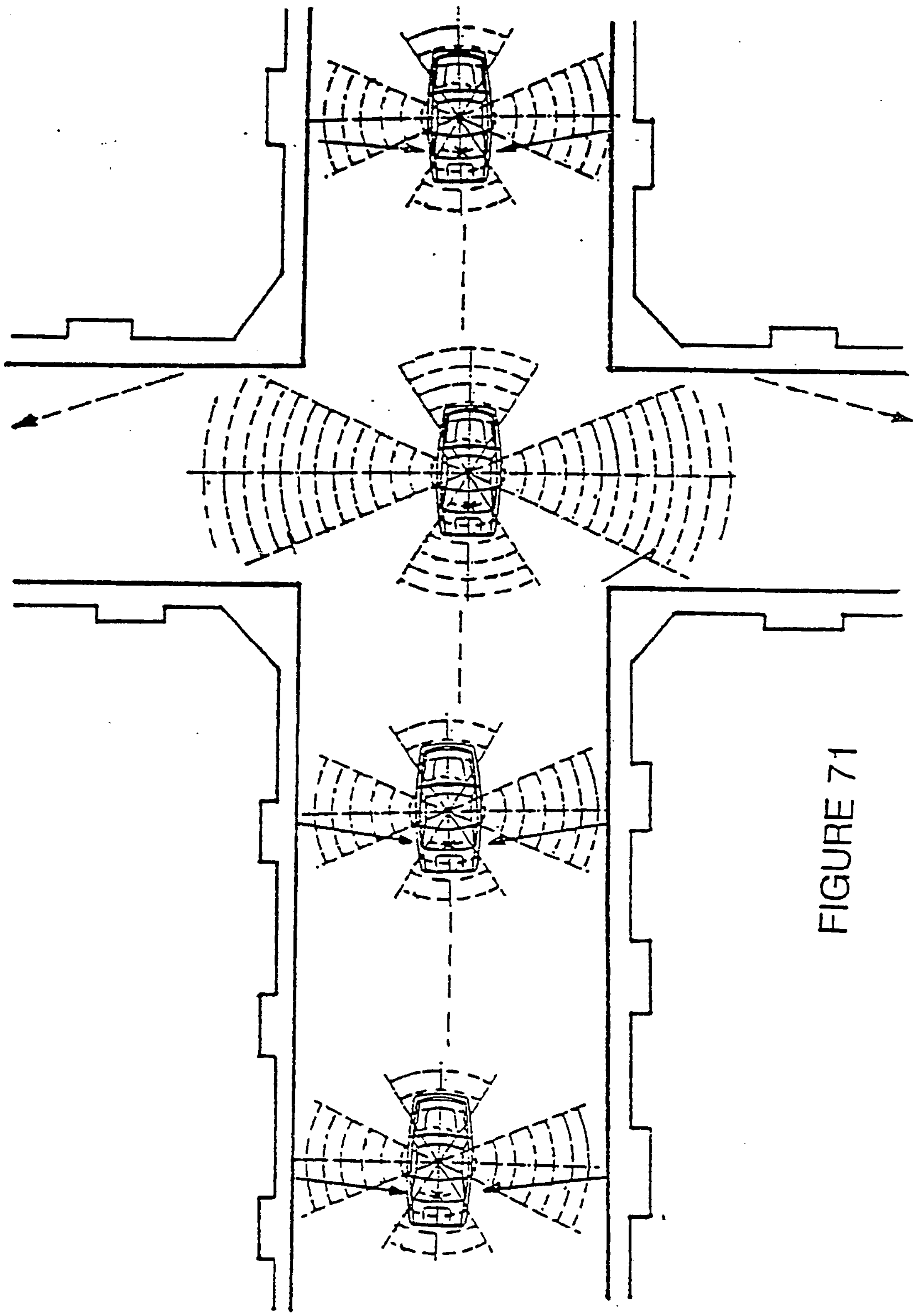


FIGURE 71

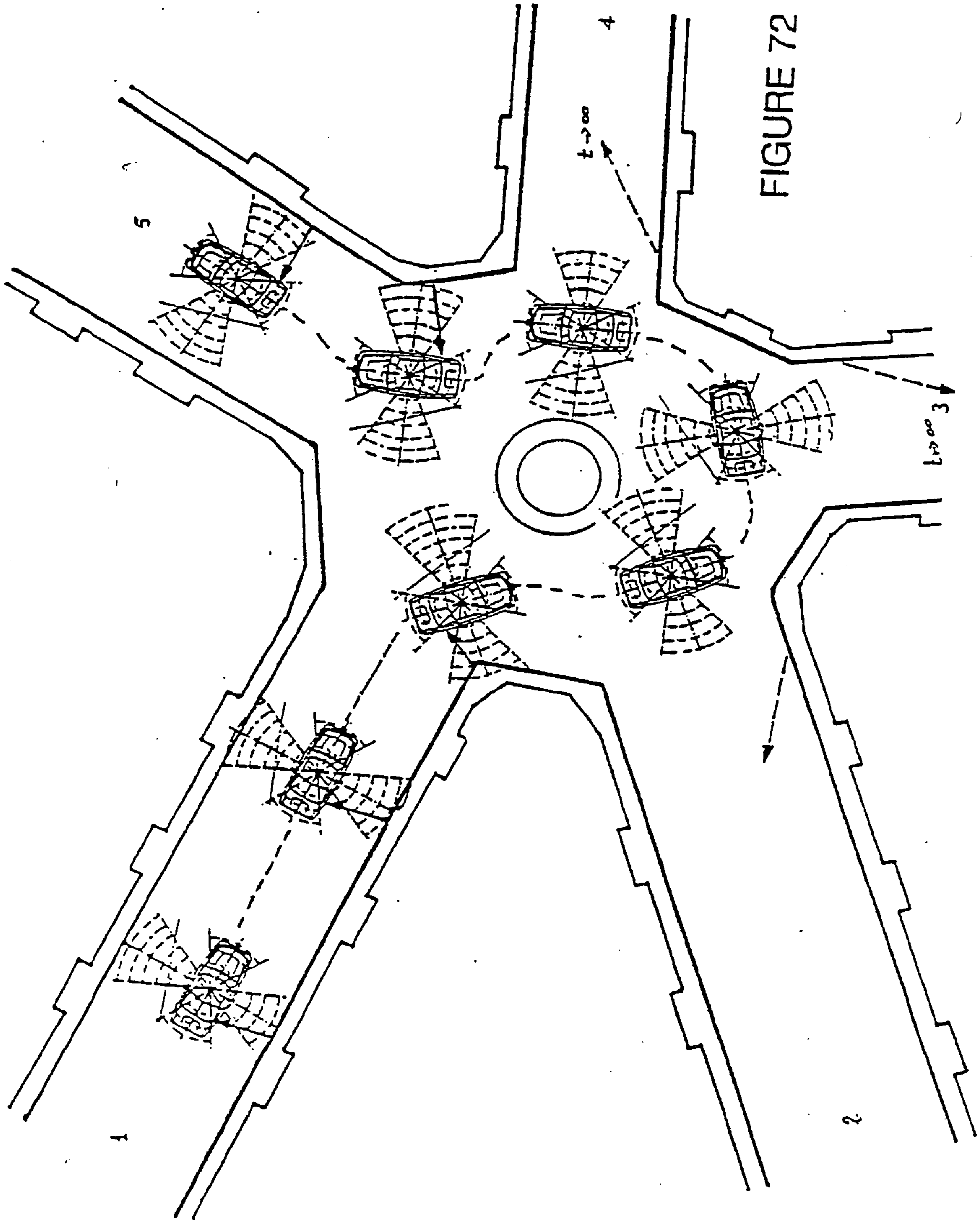


FIGURE 72

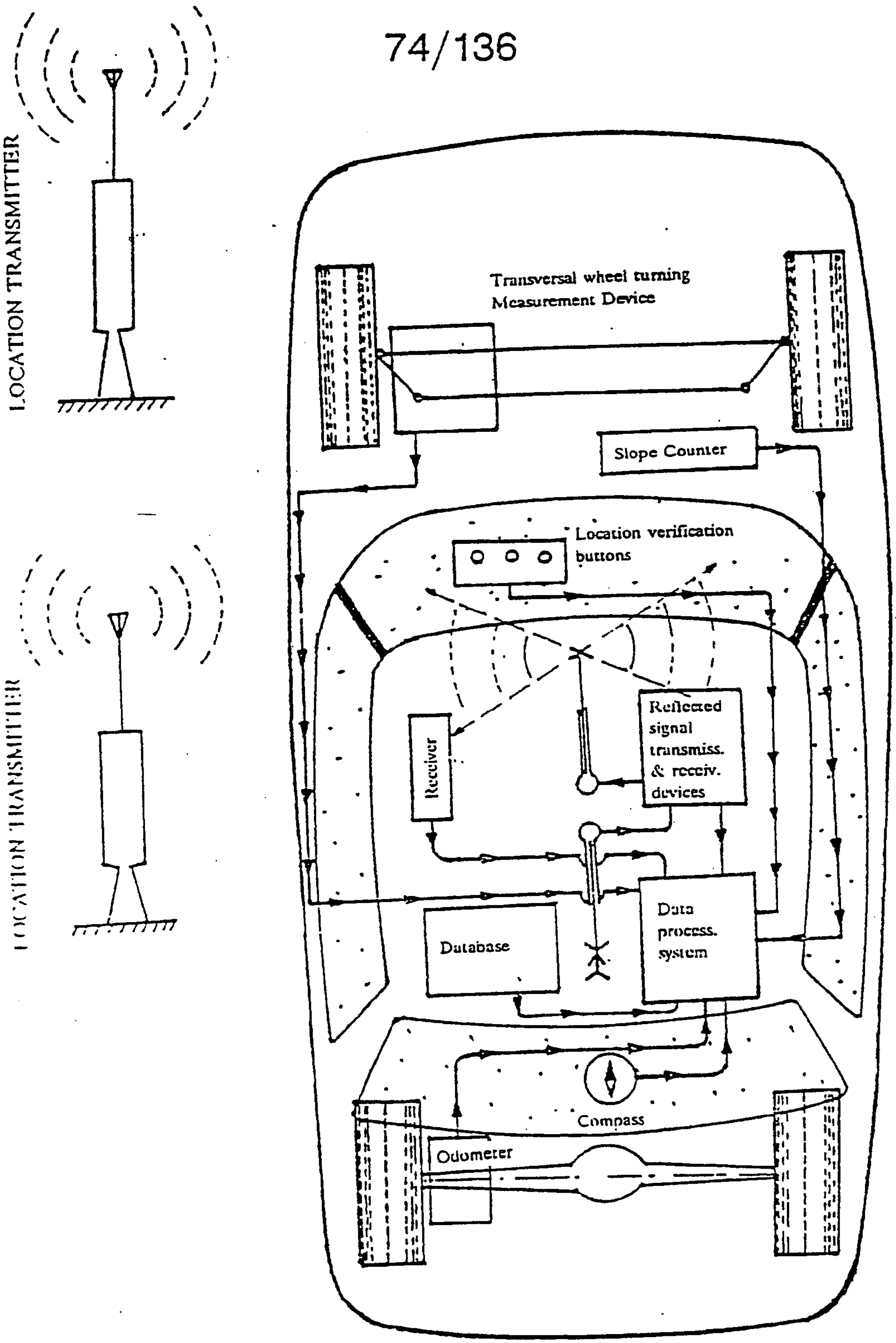

LOCATION TRANSMITTER
LOCATION TRANSMITTER
Transversal wheel turning Measurement Device
Slope Counter
Location verification buttons
Reflected signal transmiss. & receiv. devices
Receiver
Database
Data process. system
Compass
Odometer

FIGURE 73

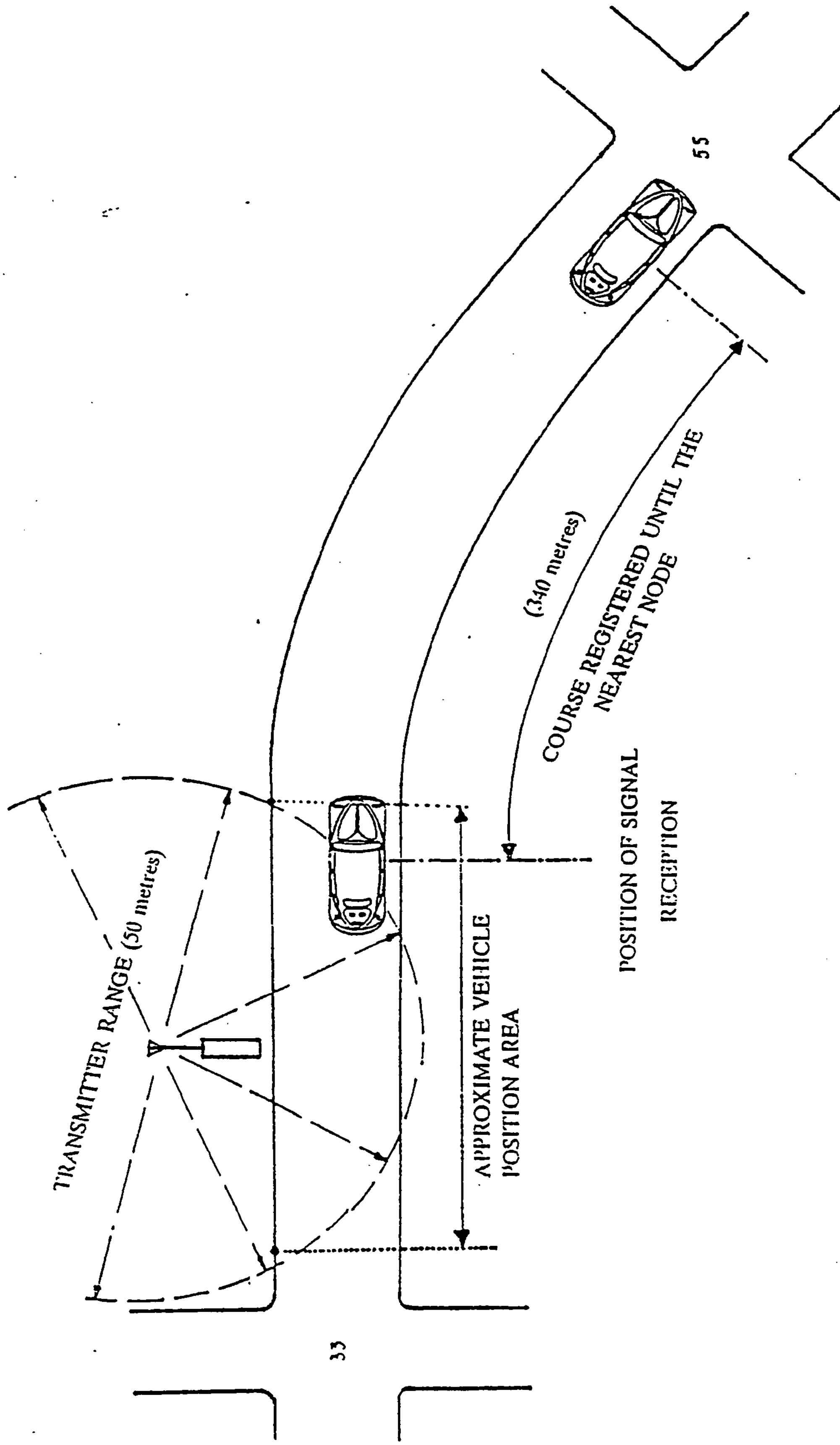

55
COURSE REGISTERED UNTIL THE NEAREST NODE
(340 metres)
POSITION OF SIGNAL RECEPTION
TRANSMITTER RANGE (50 metres)
APPROXIMATE VEHICLE POSITION AREA
33

FIGURE 74

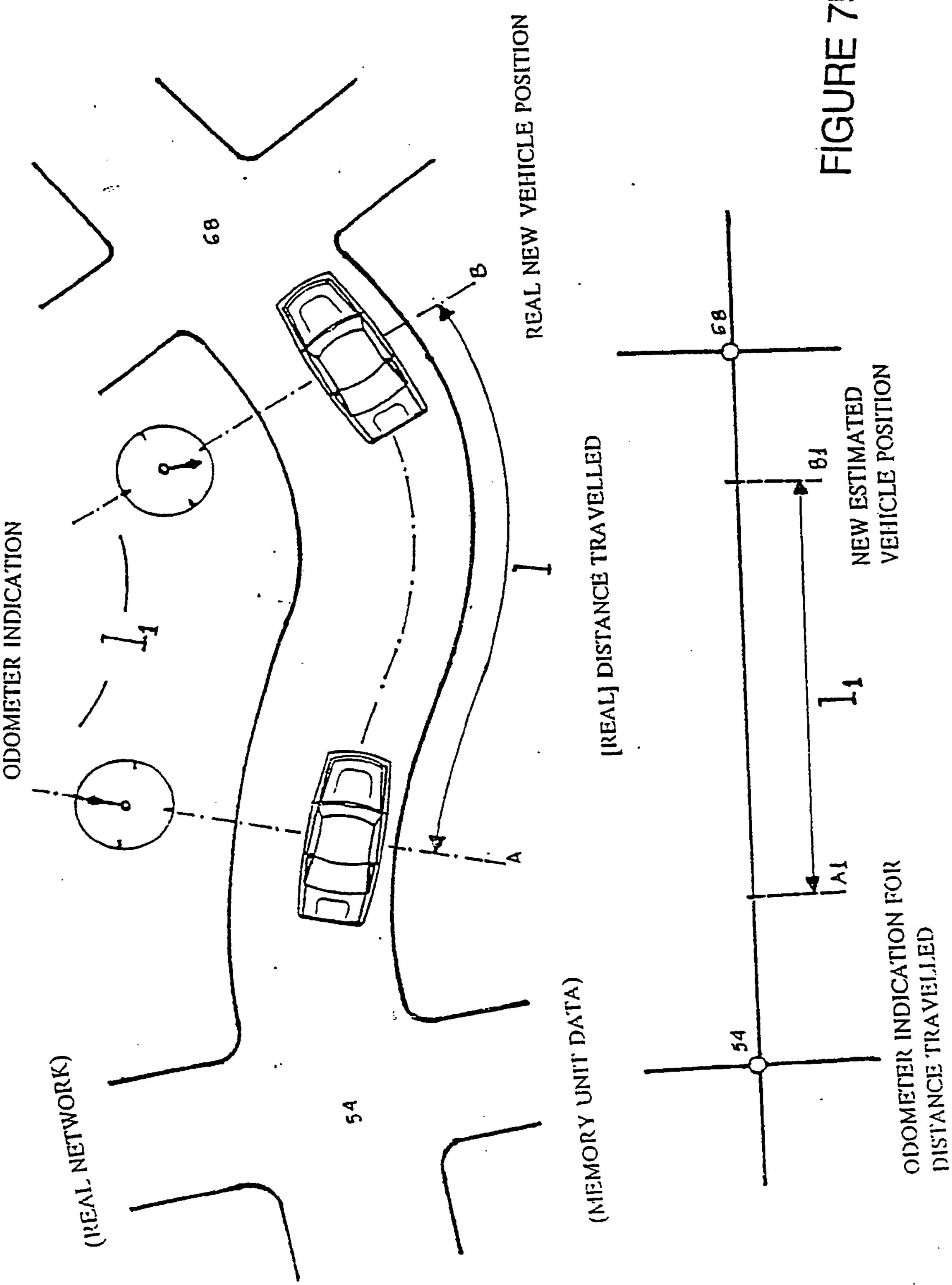

REAL NEW VEHICLE POSITION
68
B
ODOMETER INDICATION
l_1
l
[REAL] DISTANCE TRAVELLED
A
54
(REAL NETWORK)
(MEMORY UNIT DATA)
68
B1
NEW ESTIMATED
VEHICLE POSITION
l_1
A1
54
ODOMETER INDICATION FOR
DISTANCE TRAVELLED

FIGURE 75

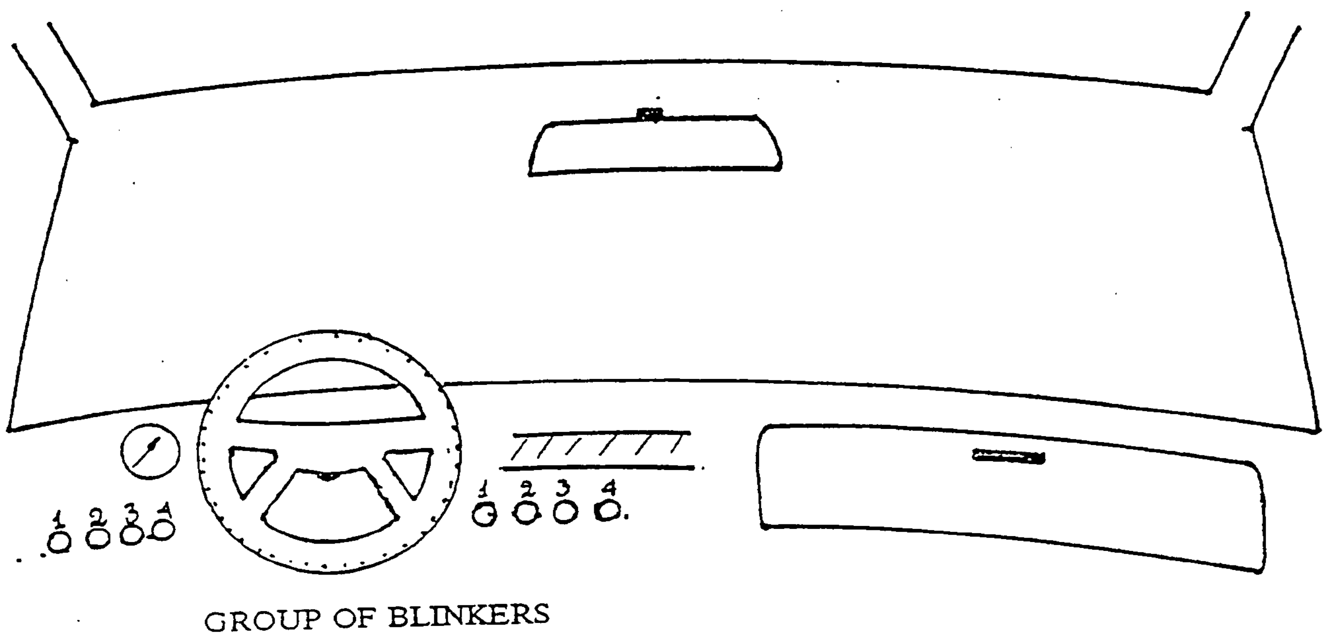


FIGURE 76

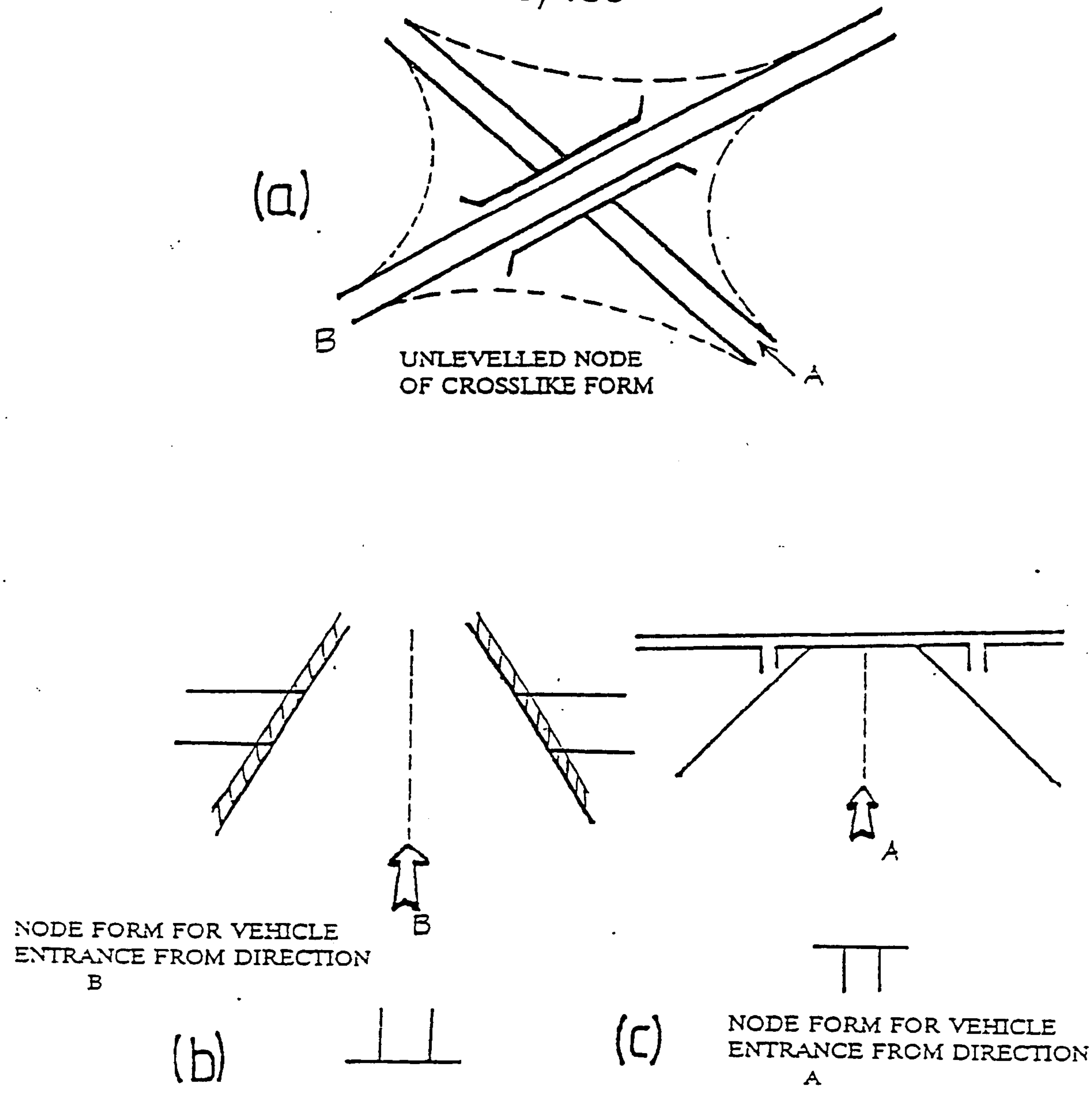

(a)
B
A
UNLEVELLED NODE
OF CROSSLIKE FORM
B
A
NODE FORM FOR VEHICLE
ENTRANCE FROM DIRECTION
B
(b)
(c)
NODE FORM FOR VEHICLE
ENTRANCE FROM DIRECTION
A

FIGURE 77

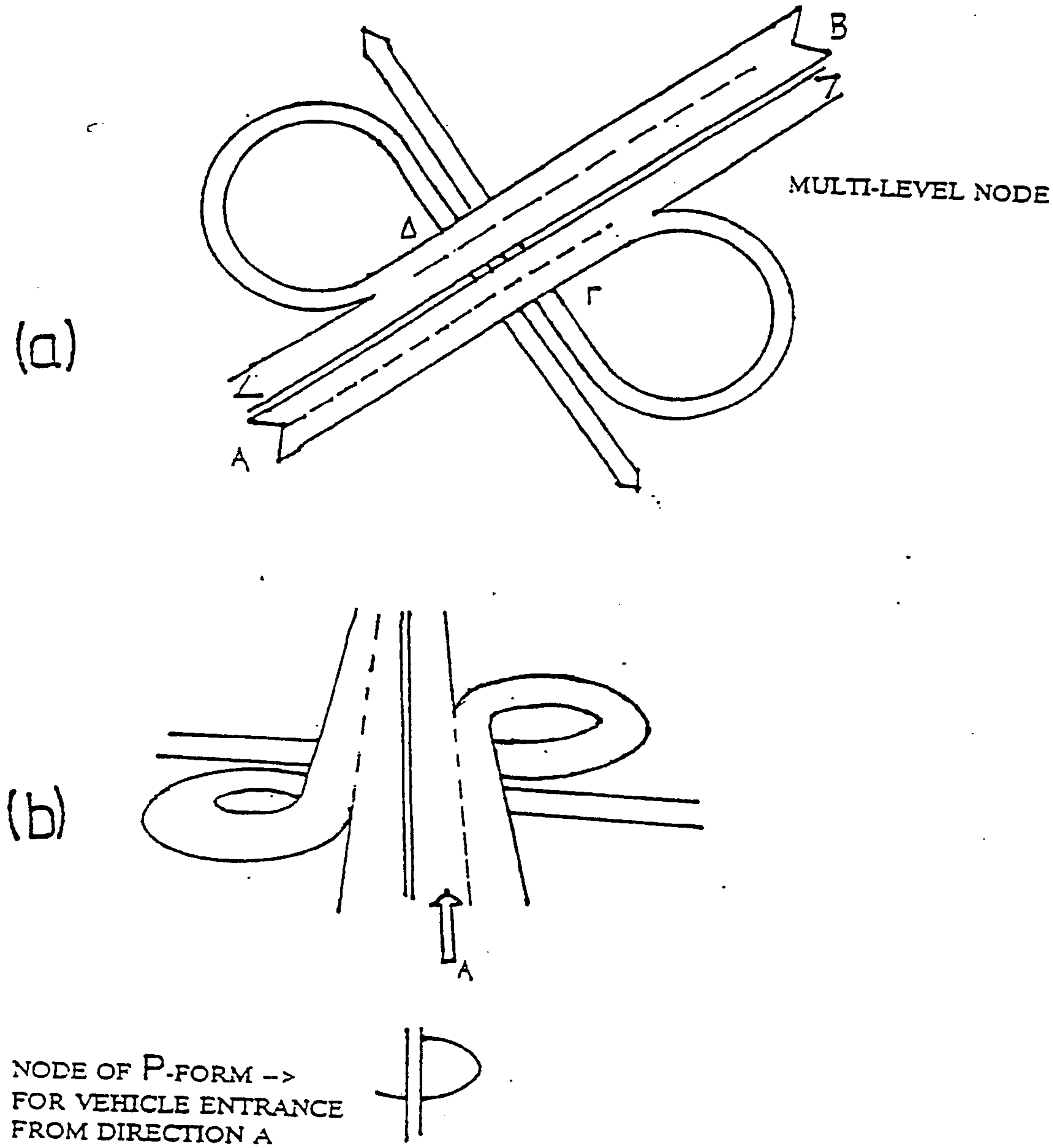

B
MULTI-LEVEL NODE
Δ
Γ
(a)
A
(b)
A
(c)
NODE OF P-FORM -->
FOR VEHICLE ENTRANCE
FROM DIRECTION A

FIGURE 78

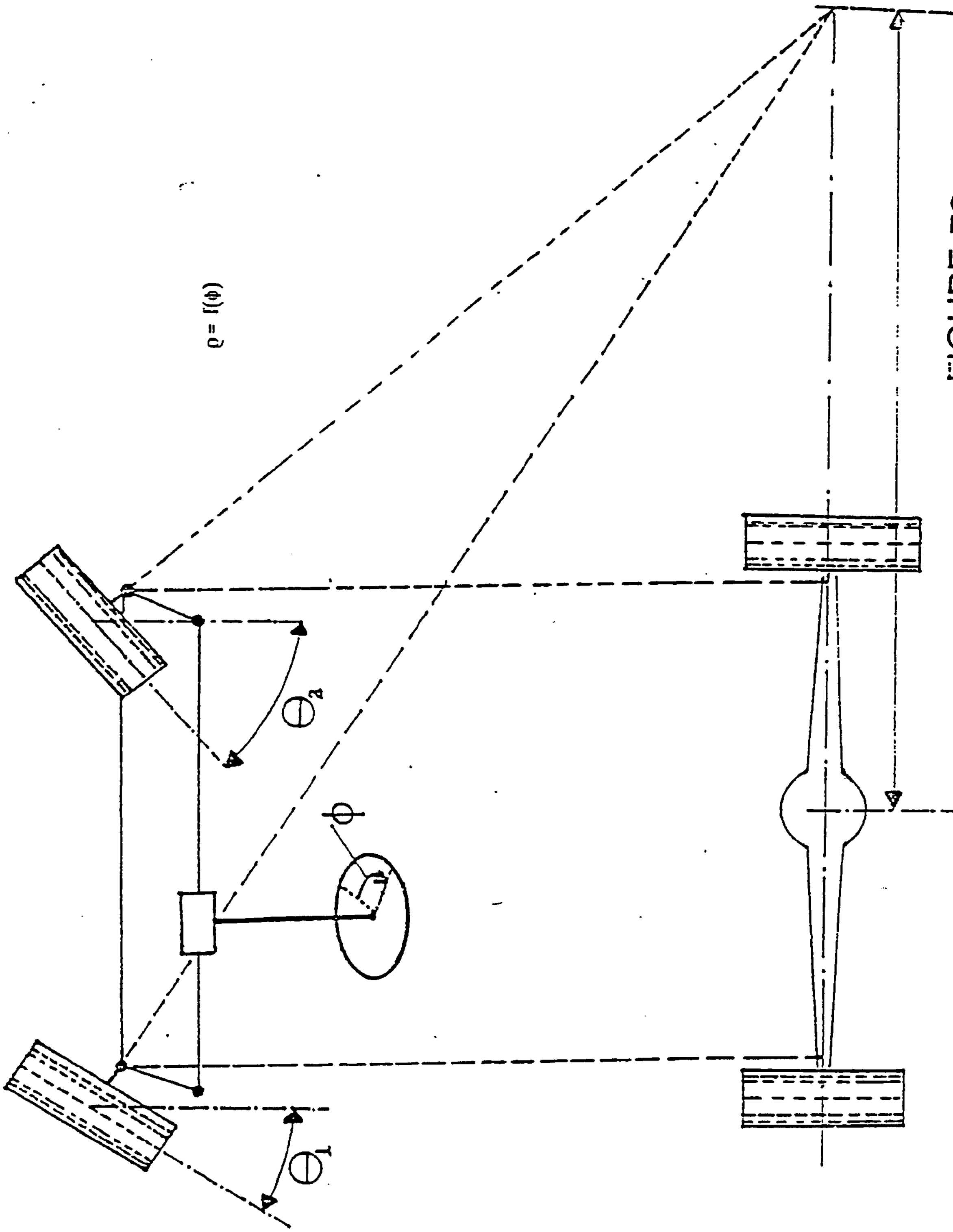


FIGURE 79

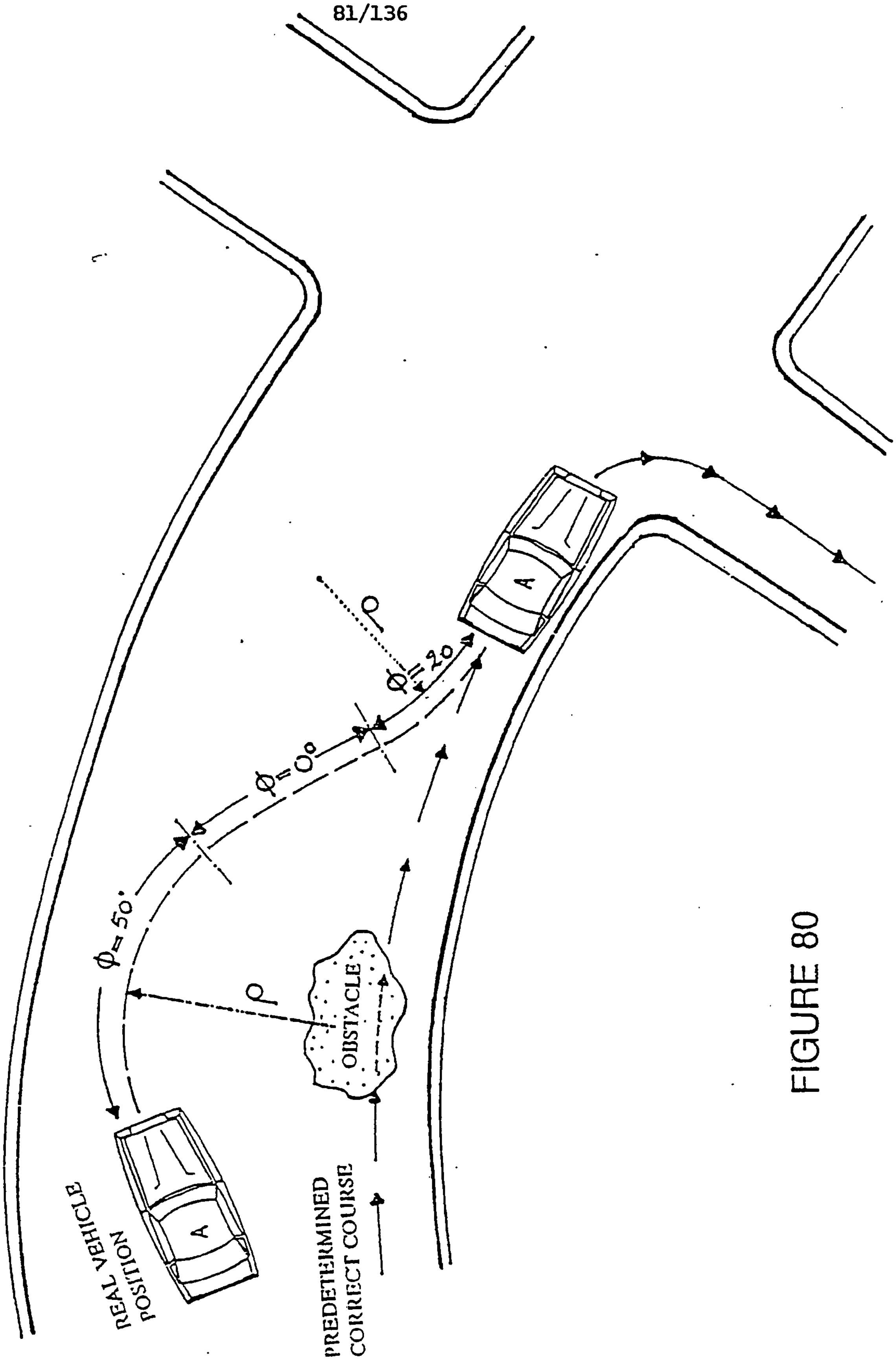

REAL VEHICLE POSITION
PREDETERMINED CORRECT COURSE
OBSTACLE
A
A
φ=50°
φ=0°
φ=20
ρ
ρ

FIGURE 80

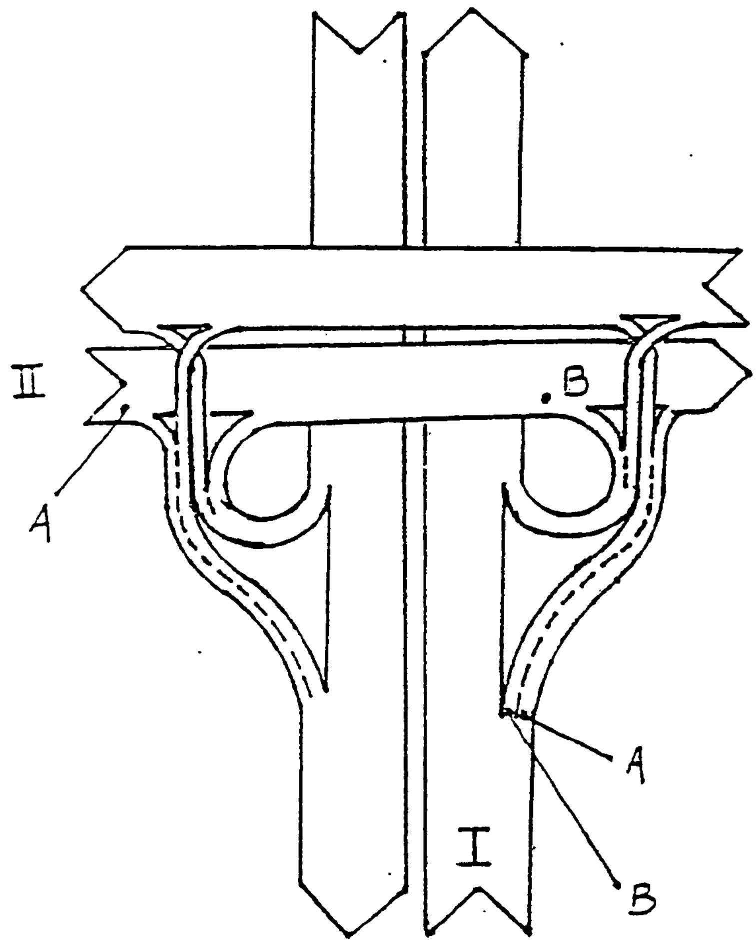


FIGURE 81

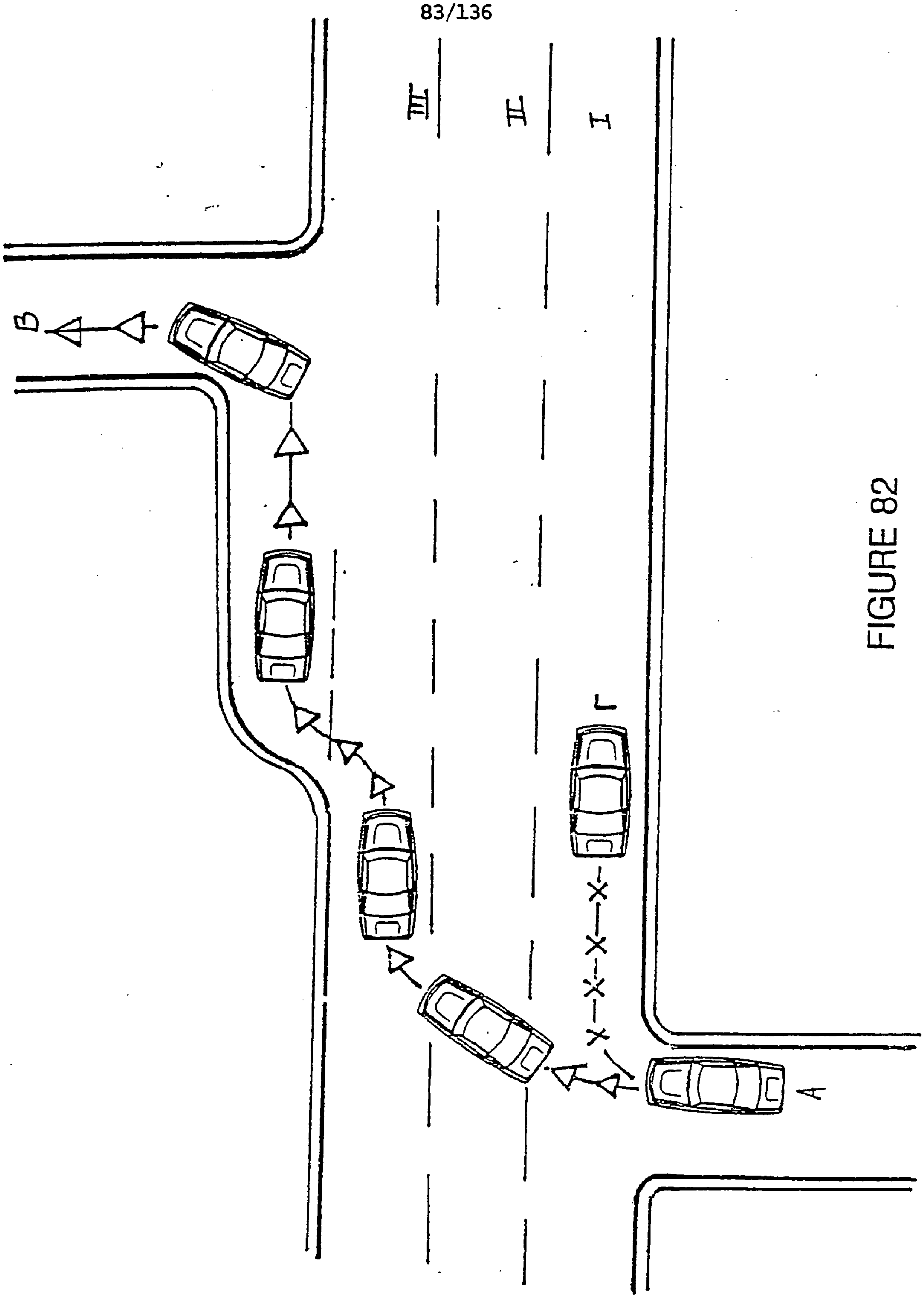


FIGURE 82

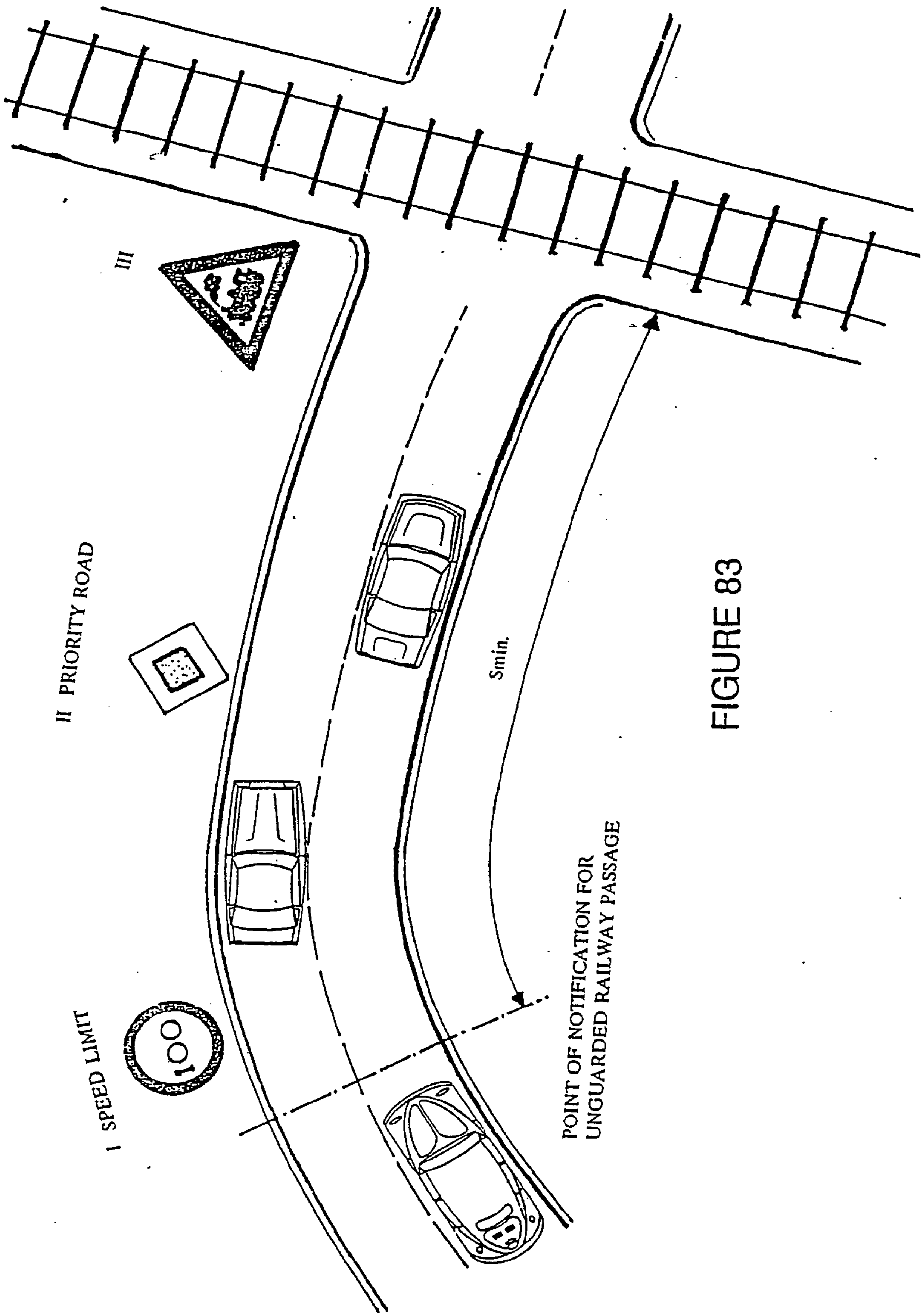

I SPEED LIMIT
100
II PRIORITY ROAD
III
Smin.
POINT OF NOTIFICATION FOR
UNGUARDED RAILWAY PASSAGE

FIGURE 83

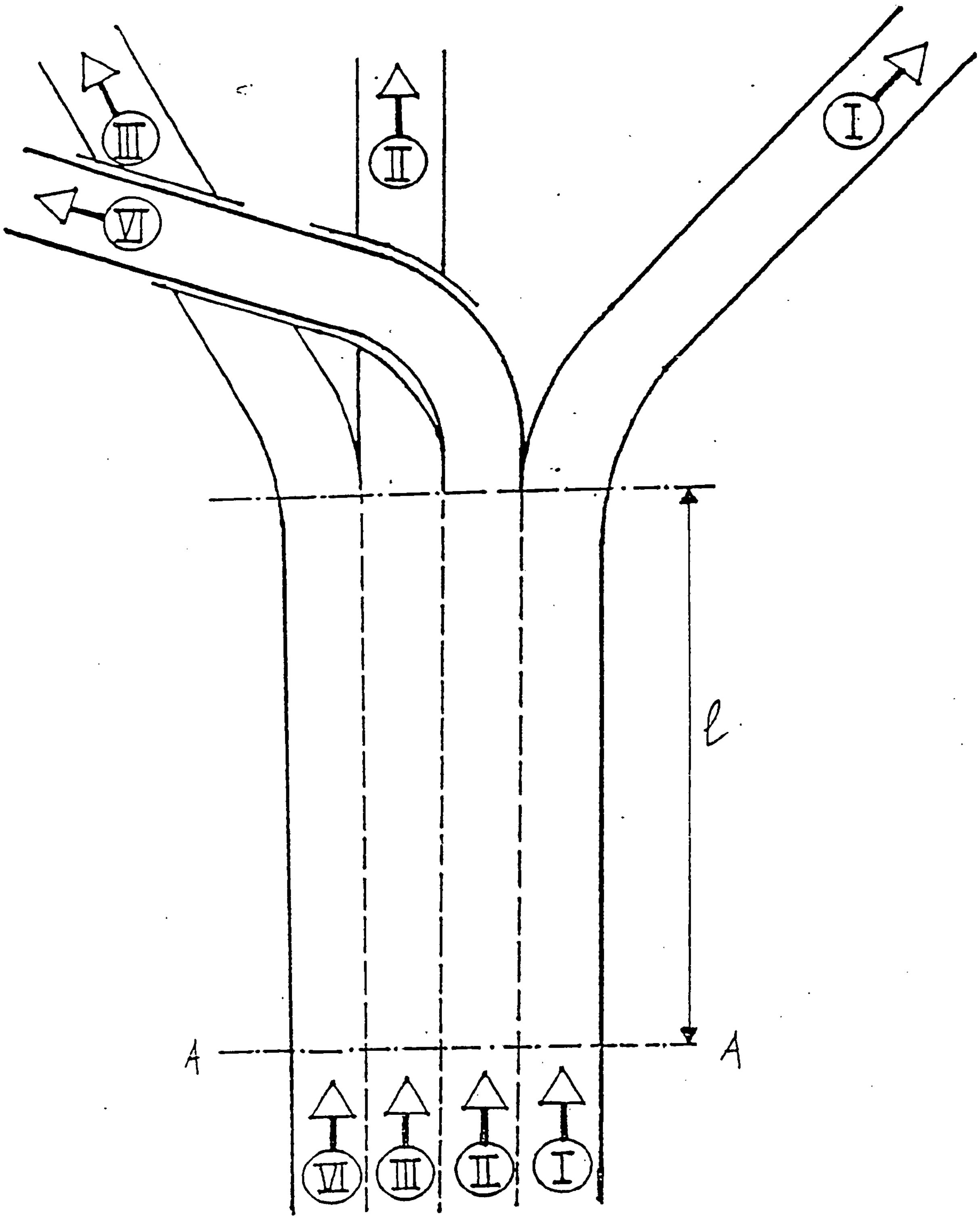


FIGURE 84

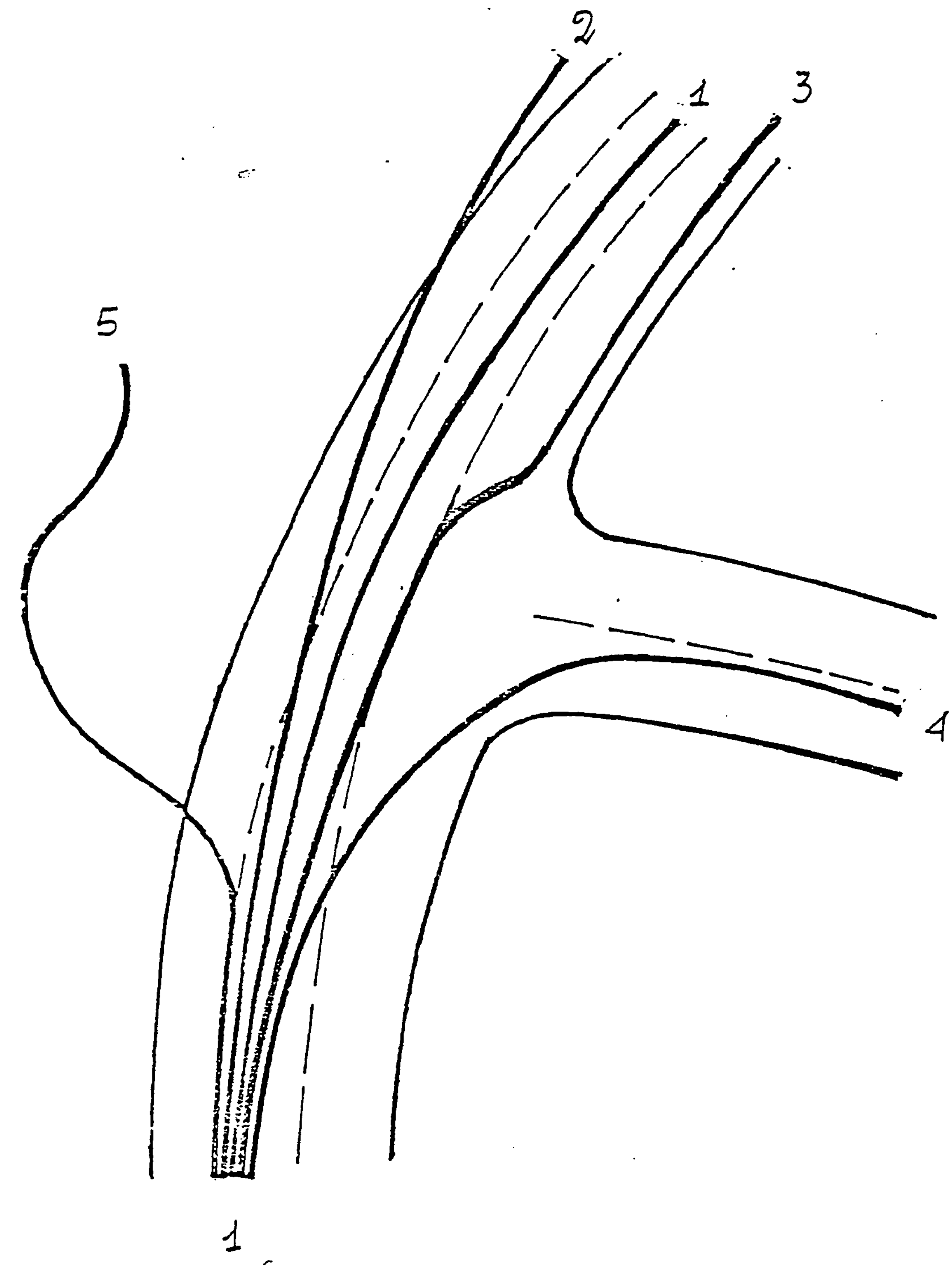


FIGURE 85

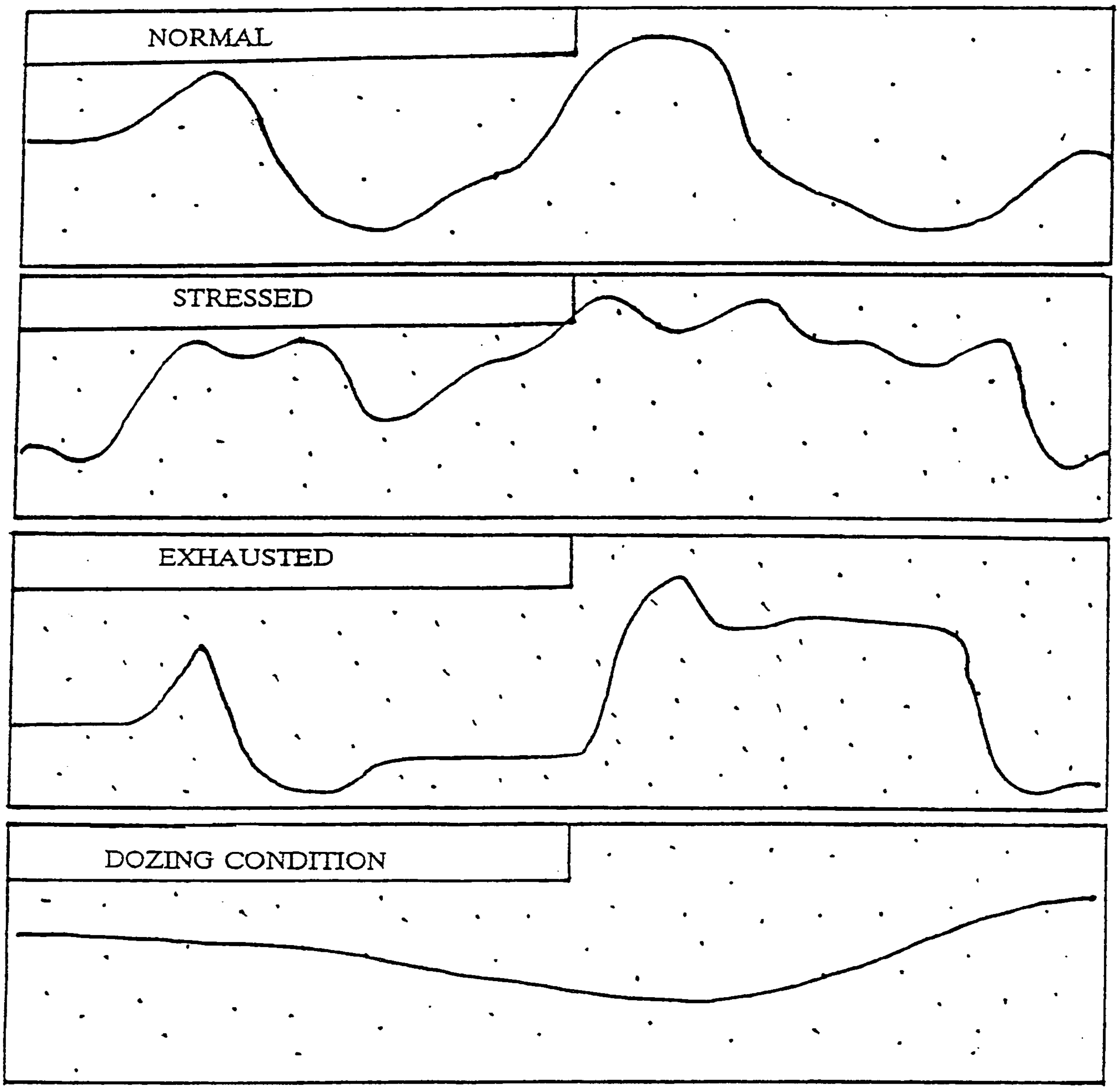


FIGURE 86

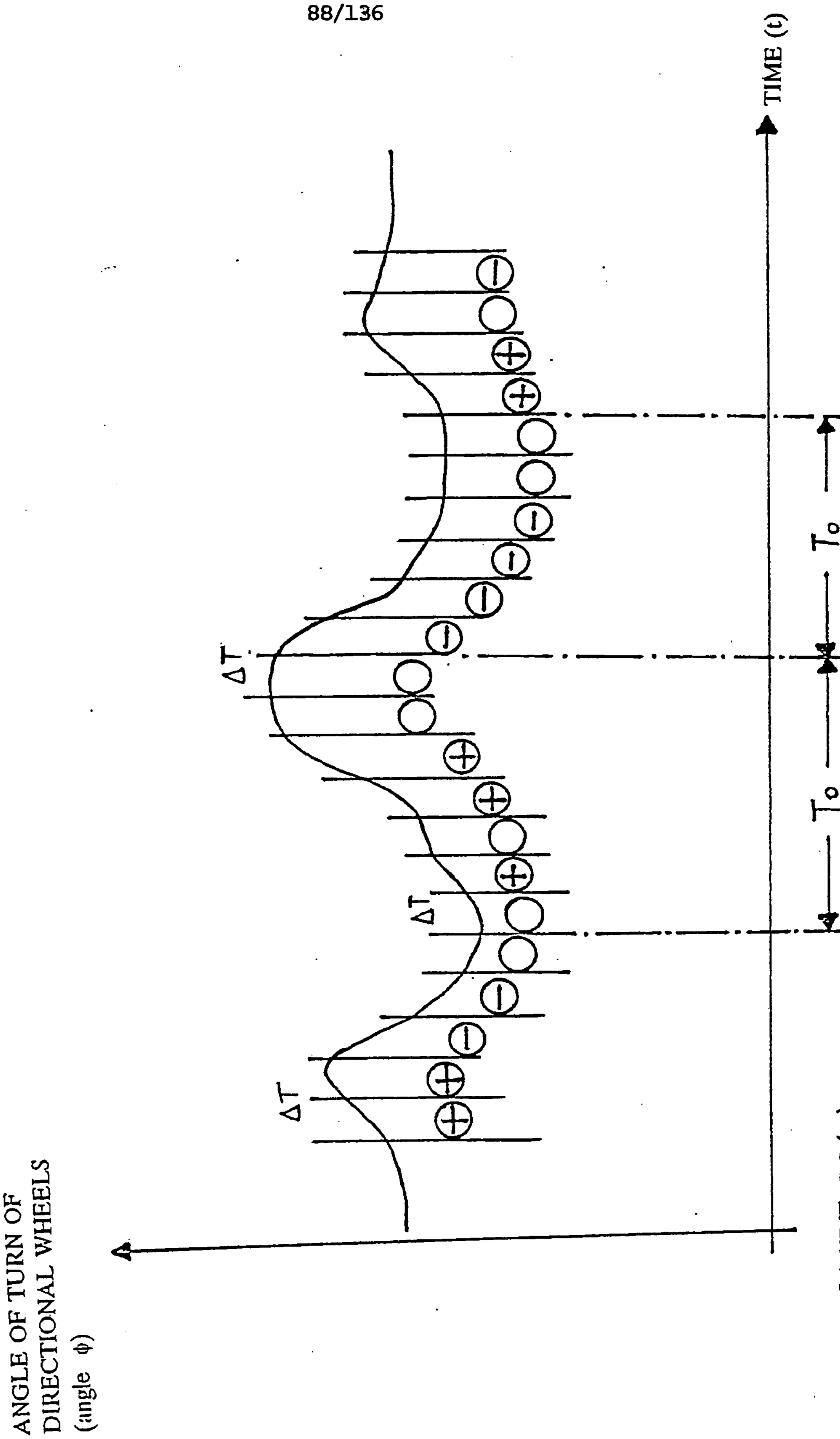

ANGLE OF TURN OF
DIRECTIONAL WHEELS
(angle φ)
TIME (t)
ΔT
ΔT
ΔT
To
To
+
-

FIGURE 86(a)

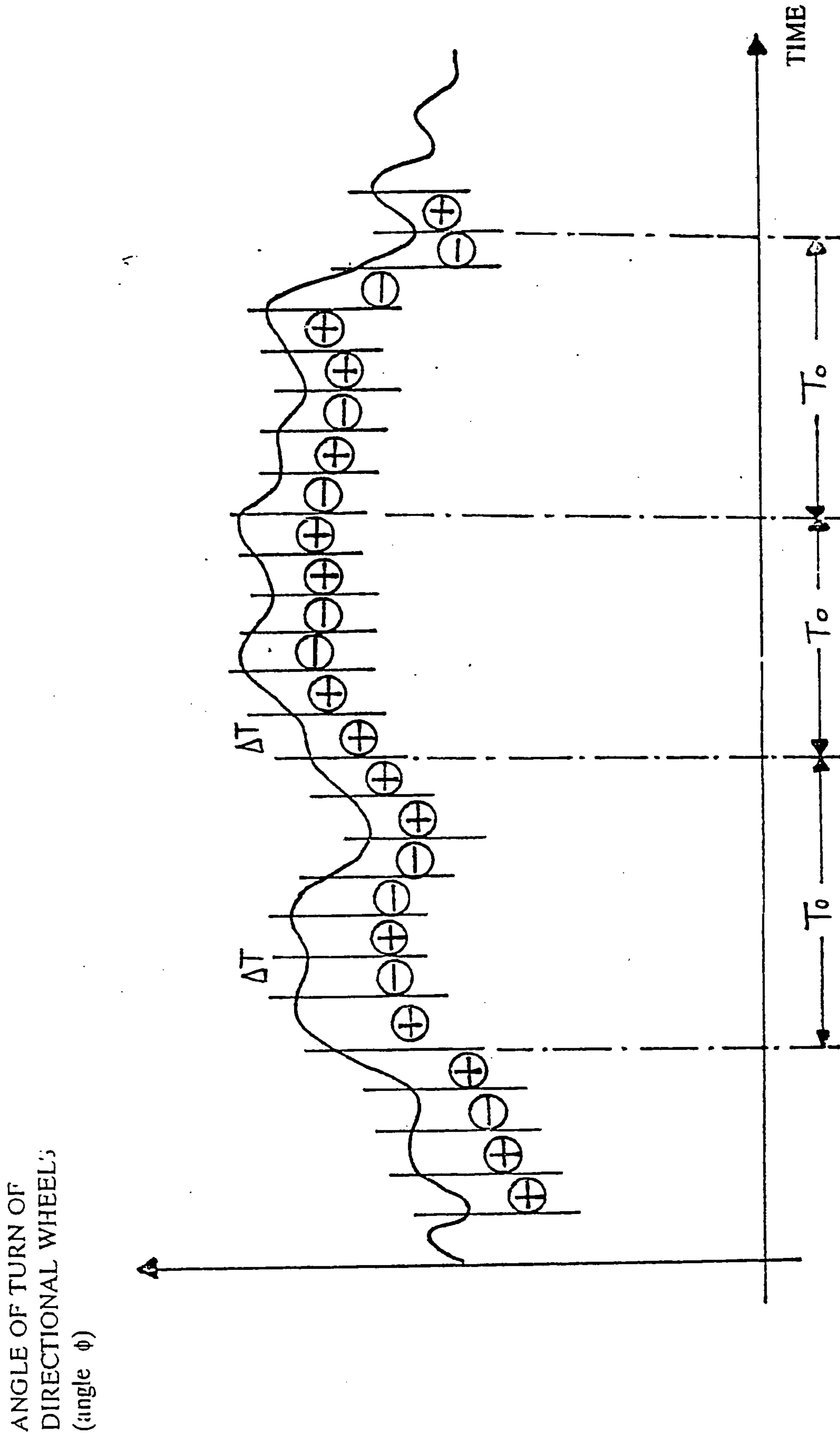

ANGLE OF TURN OF
DIRECTIONAL WHEELS
(angle φ)
TIME
ΔT
ΔT
To
To
To

FIGURE 86(b)

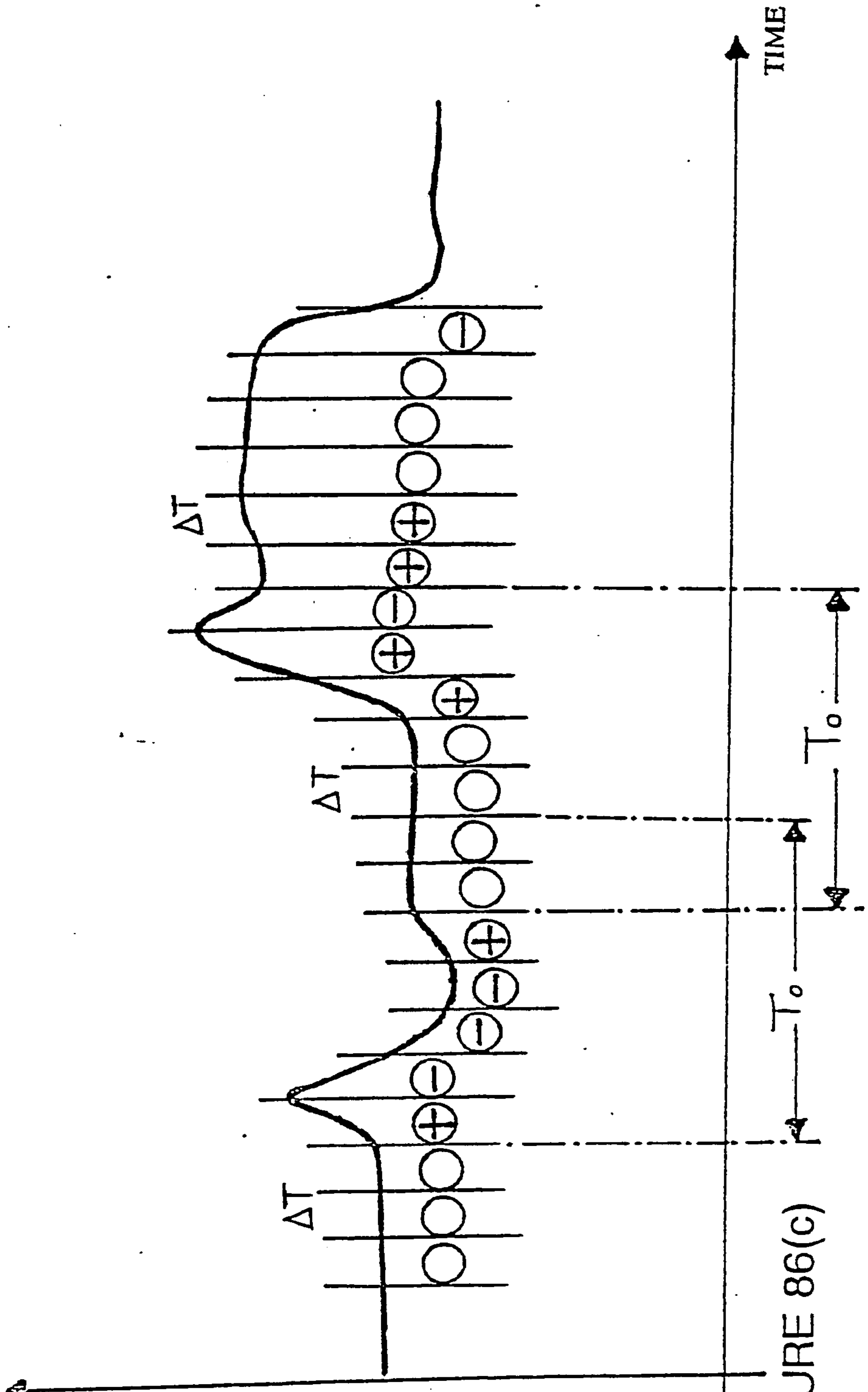


FIGURE 86(c)

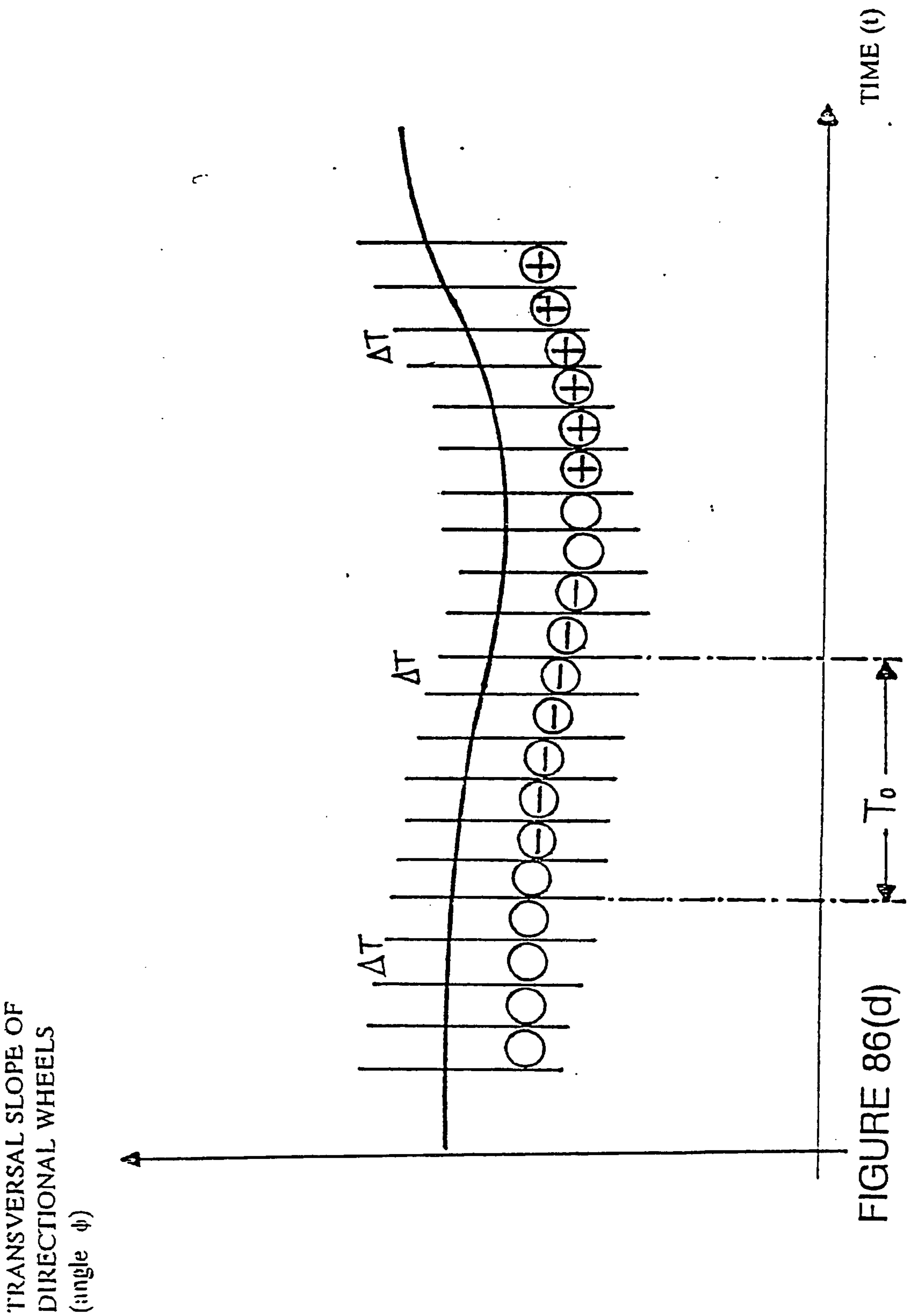

TIME (t)
ΔT
ΔT
ΔT
To
TRANSVERSAL SLOPE OF
DIRECTIONAL WHEELS
(angle φ)

FIGURE 86(d)

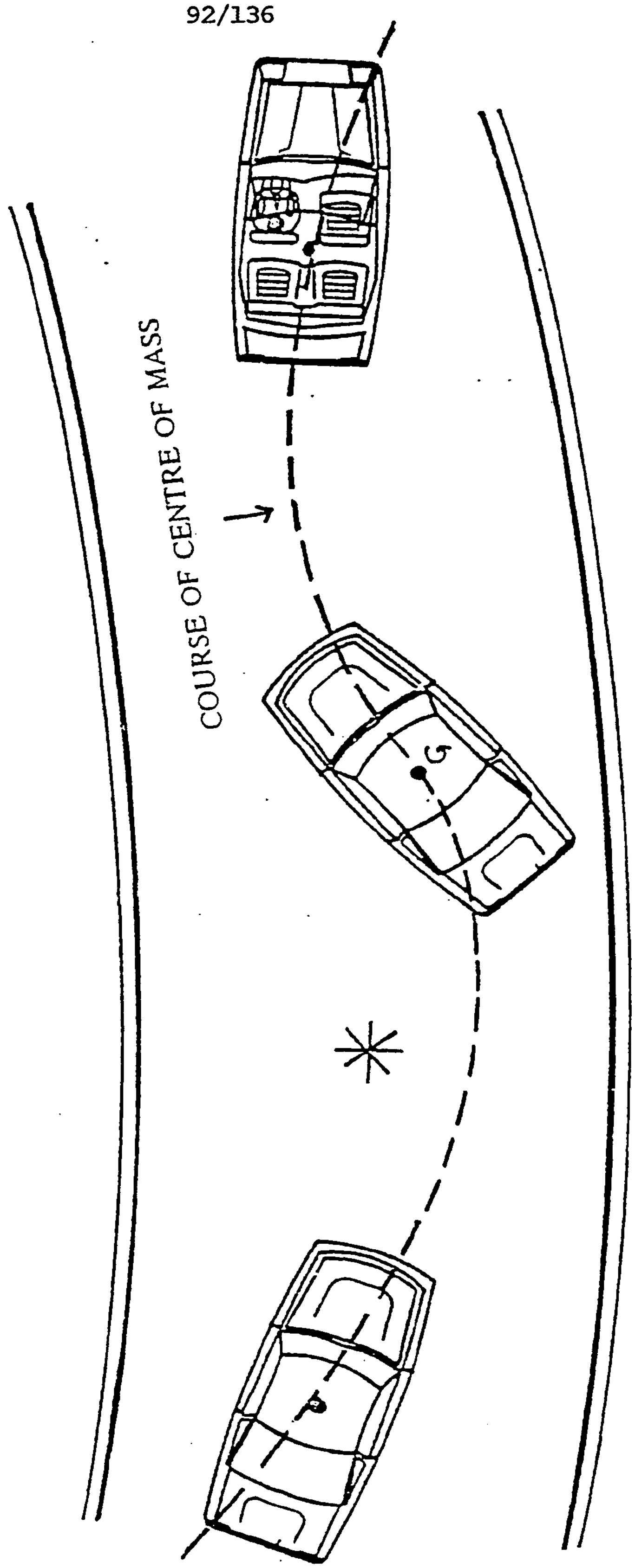


FIGURE 87

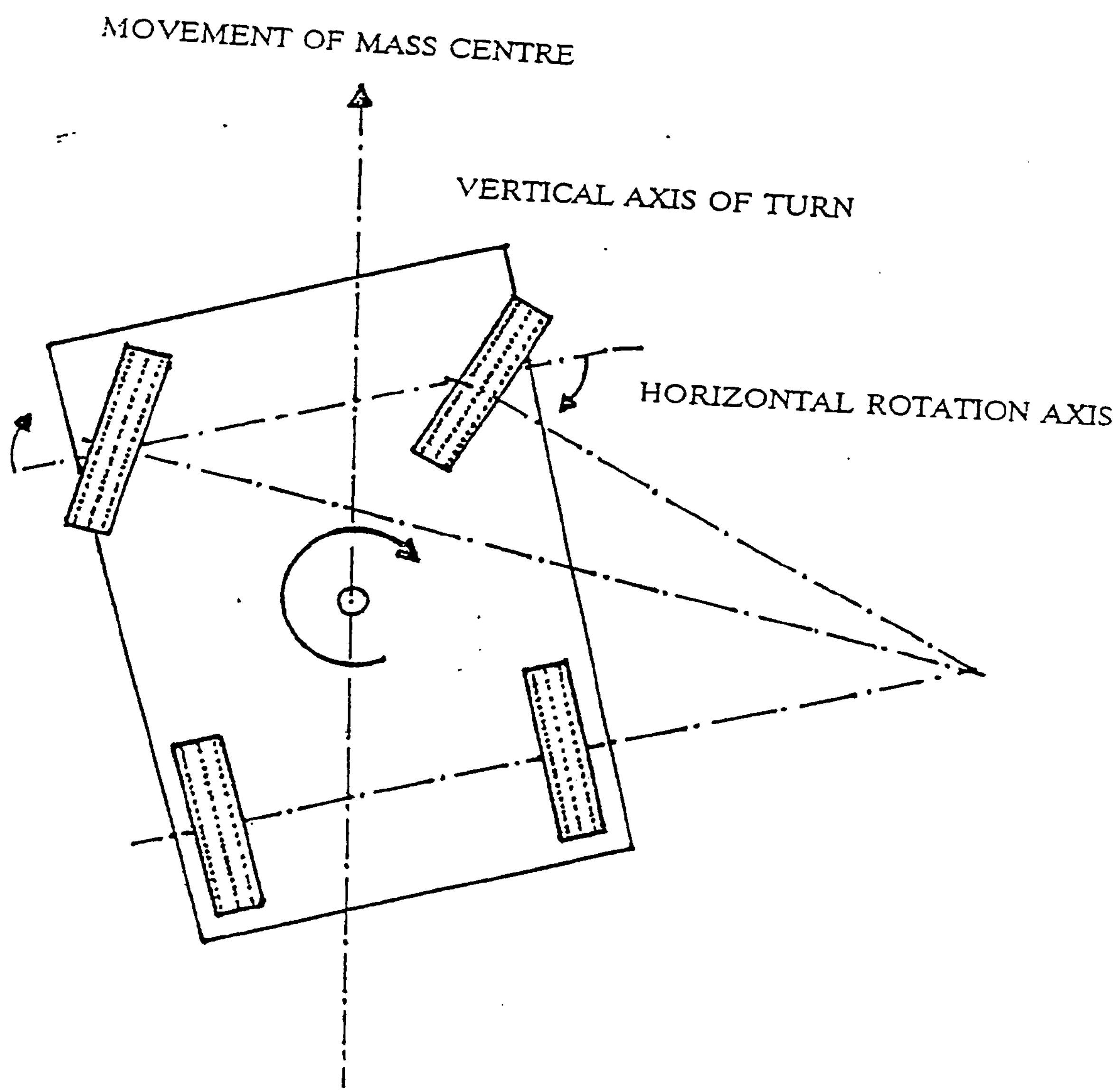

MOVEMENT OF MASS CENTRE
VERTICAL AXIS OF TURN
HORIZONTAL ROTATION AXIS

FIGURE 88

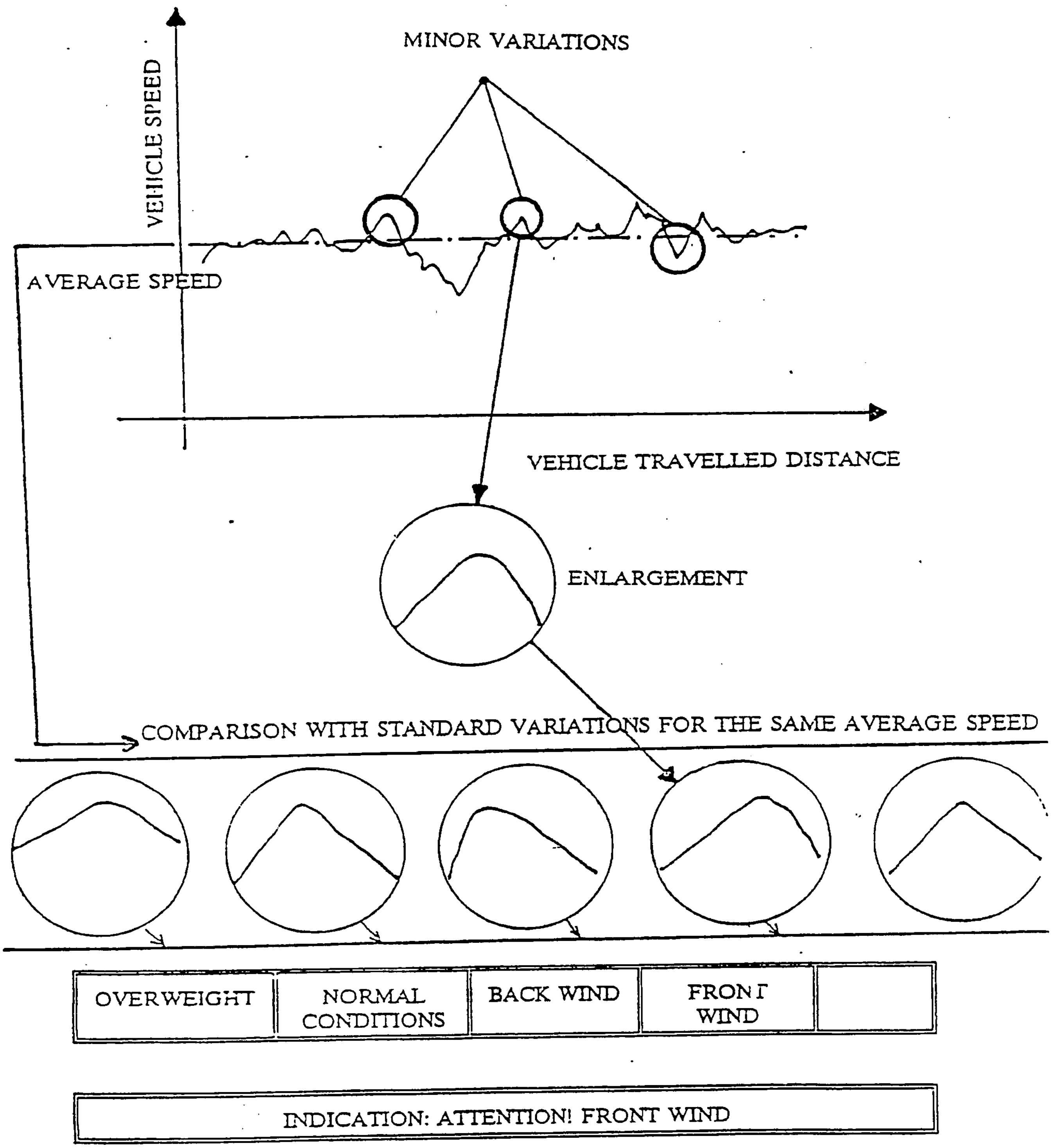

MINOR VARIATIONS
VEHICLE SPEED
AVERAGE SPEED
VEHICLE TRAVELLED DISTANCE
ENLARGEMENT
COMPARISON WITH STANDARD VARIATIONS FOR THE SAME AVERAGE SPEED
OVERWEIGHT
NORMAL CONDITIONS
BACK WIND
FRONT WIND
INDICATION: ATTENTION! FRONT WIND

FIGURE 89

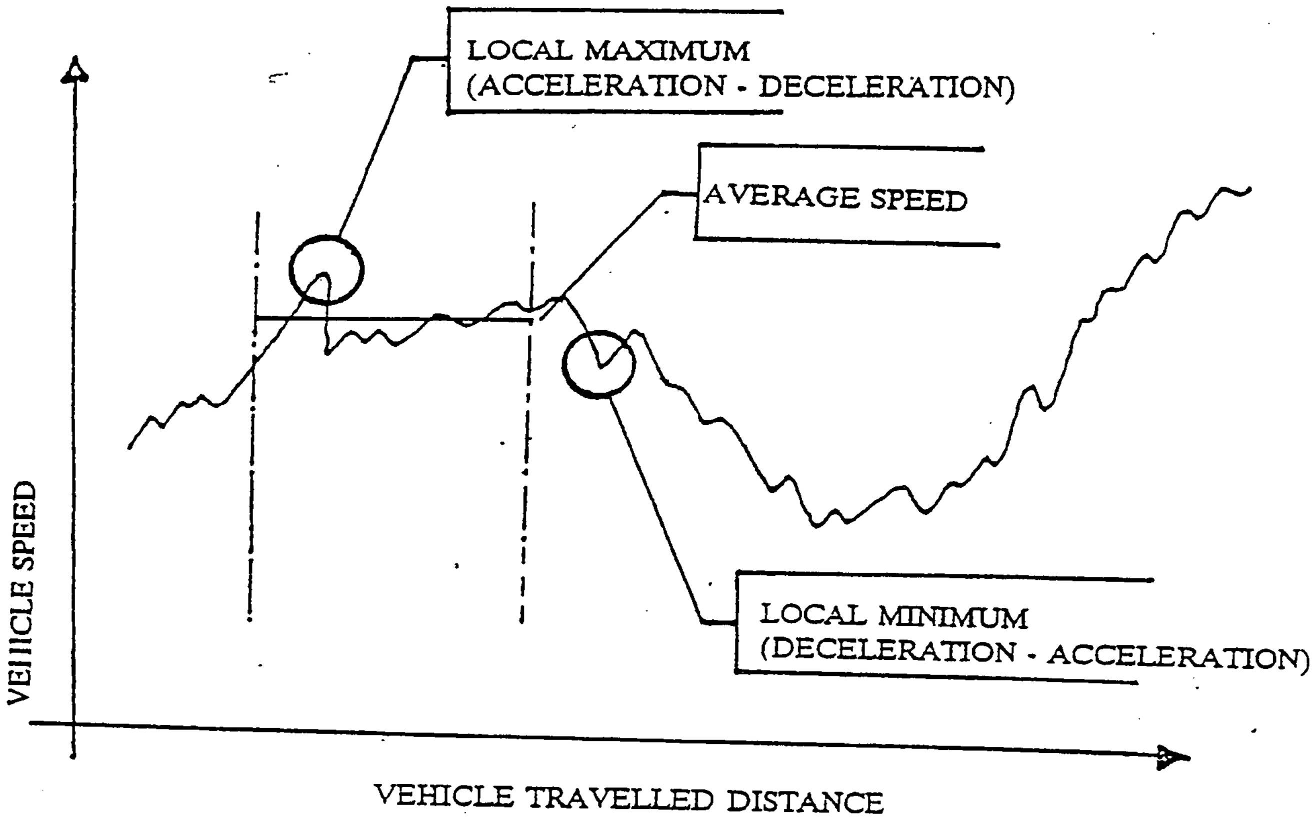

LOCAL MAXIMUM
(ACCELERATION - DECELERATION)
AVERAGE SPEED
LOCAL MINIMUM
(DECELERATION - ACCELERATION)
VEHICLE SPEED
VEHICLE TRAVELLED DISTANCE

FIGURE 90

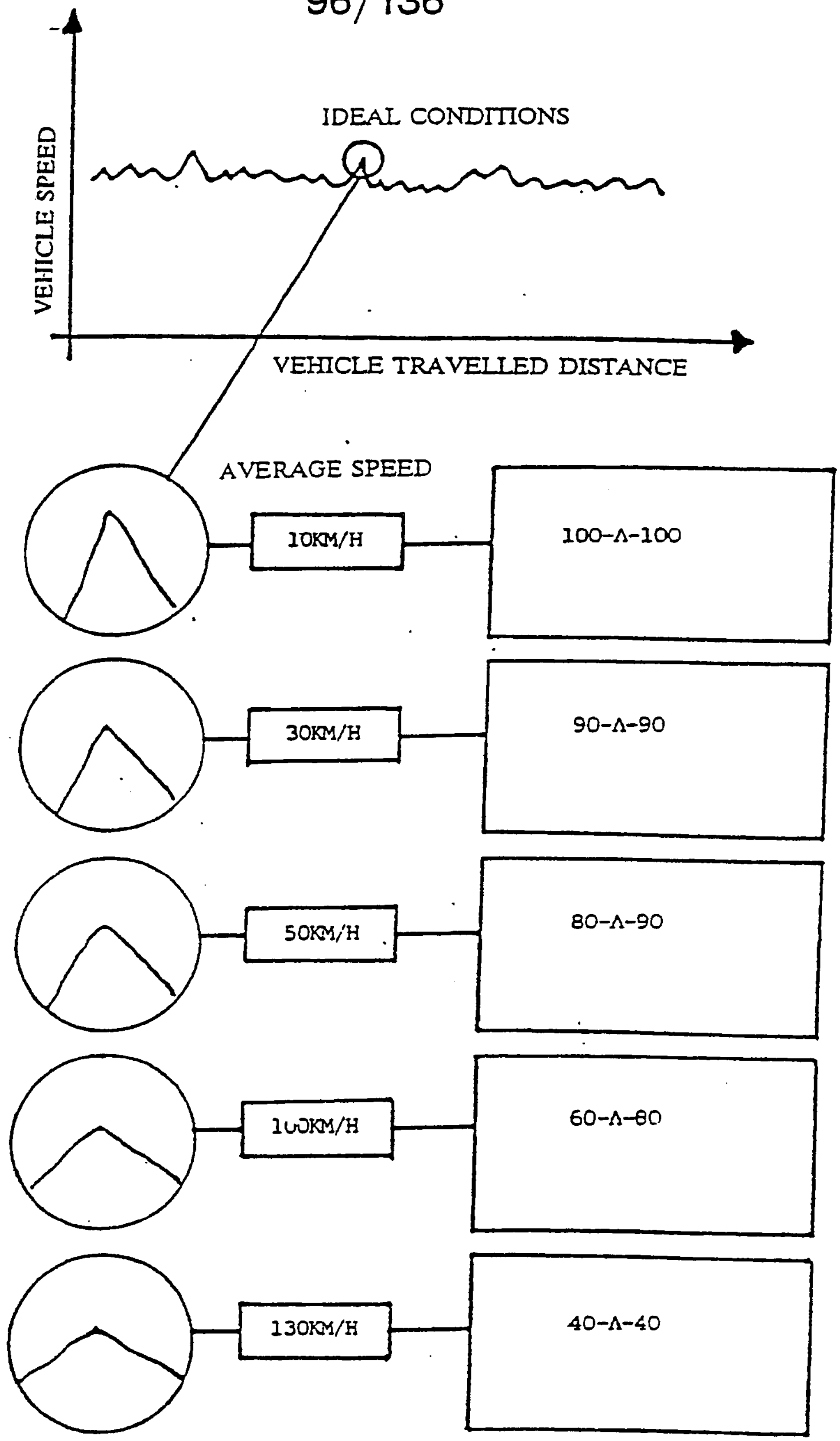

IDEAL CONDITIONS
VEHICLE SPEED
VEHICLE TRAVELLED DISTANCE
AVERAGE SPEED
10KM/H
100-Λ-100
30KM/H
90-Λ-90
50KM/H
80-Λ-90
100KM/H
60-Λ-80
130KM/H
40-Λ-40

FIGURE 91

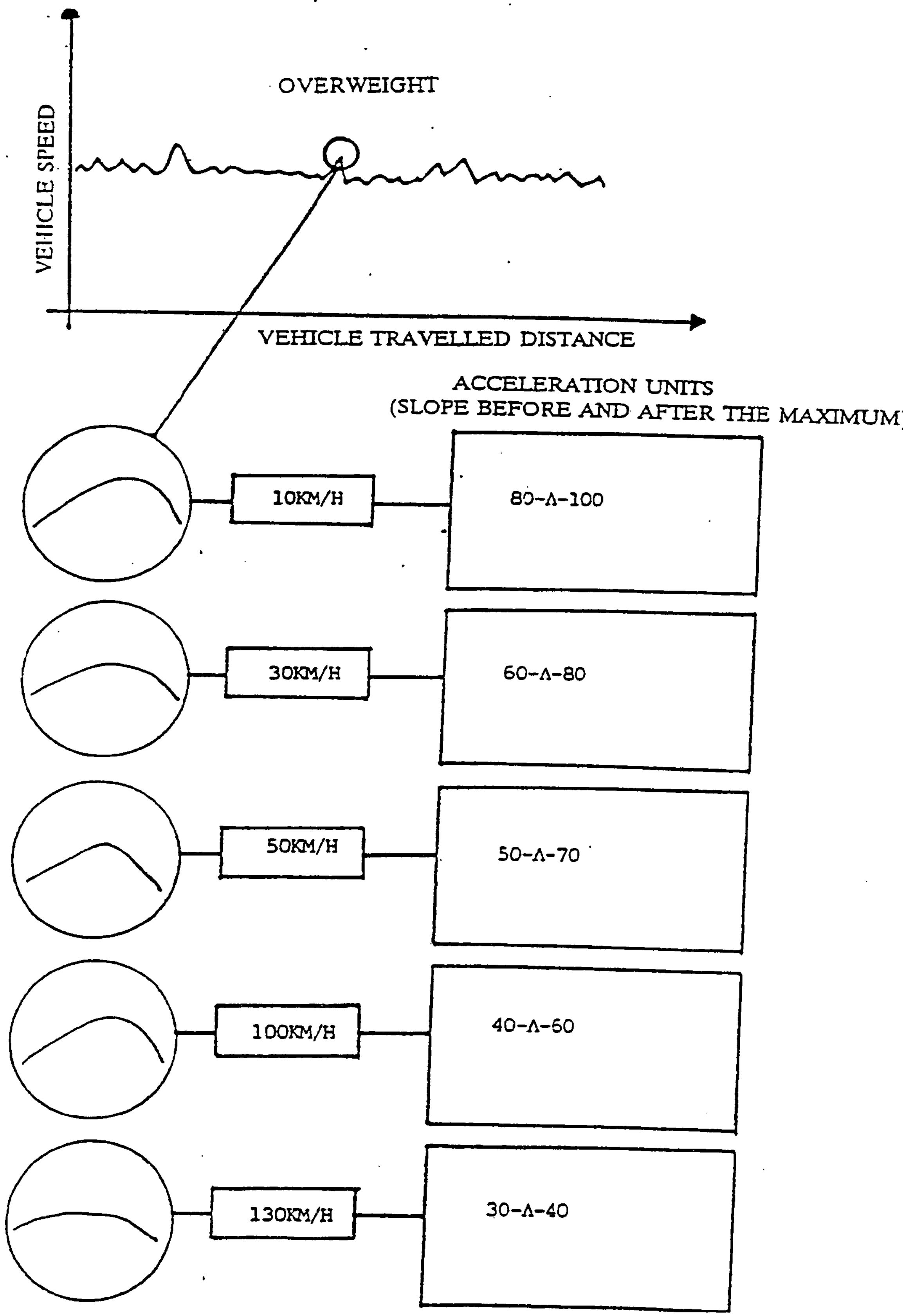

OVERWEIGHT
VEHICLE SPEED
VEHICLE TRAVELLED DISTANCE
ACCELERATION UNITS
(SLOPE BEFORE AND AFTER THE MAXIMUM)
10KM/H
80-Λ-100
30KM/H
60-Λ-80
50KM/H
50-Λ-70
100KM/H
40-Λ-60
130KM/H
30-Λ-40

FIGURE 92

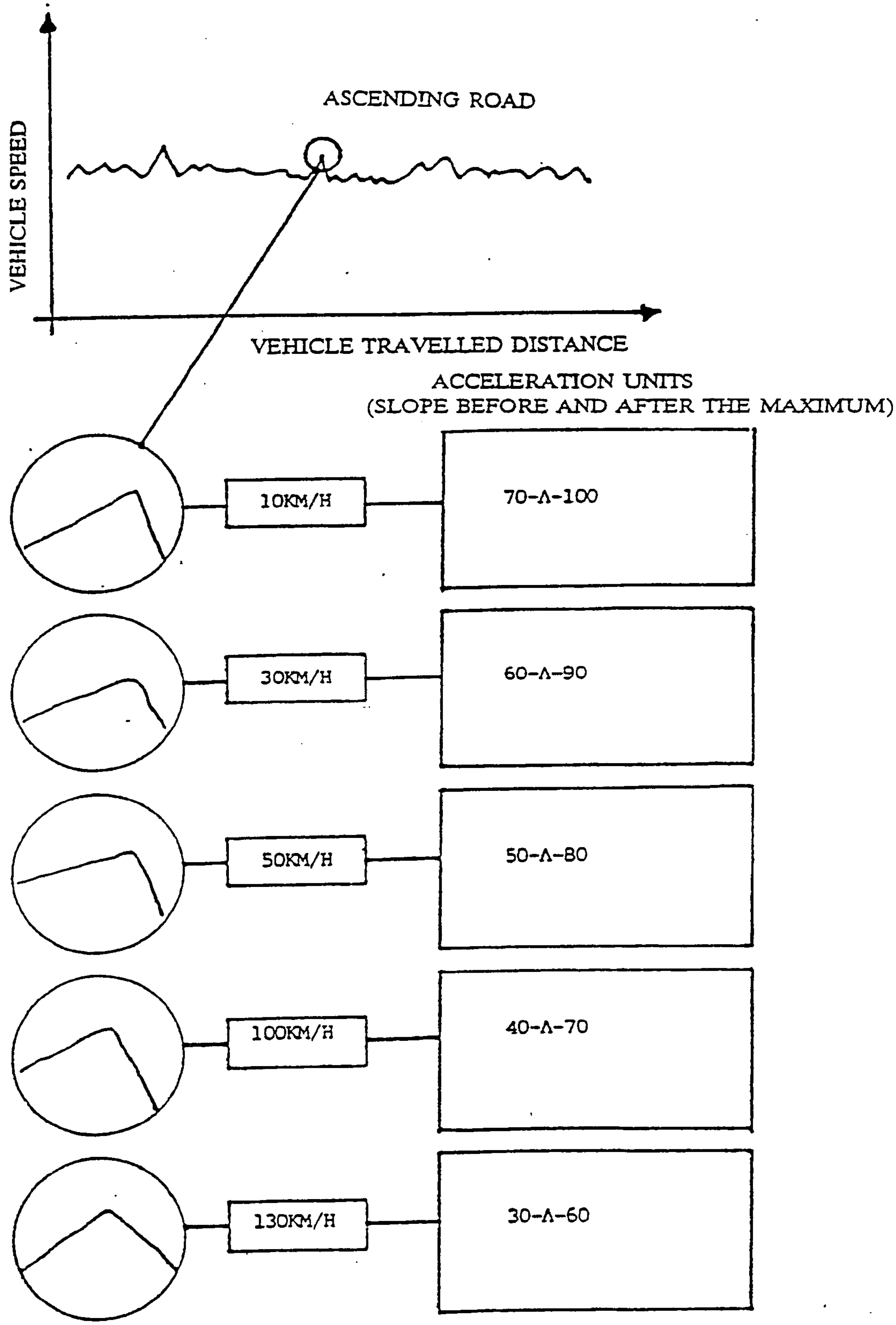
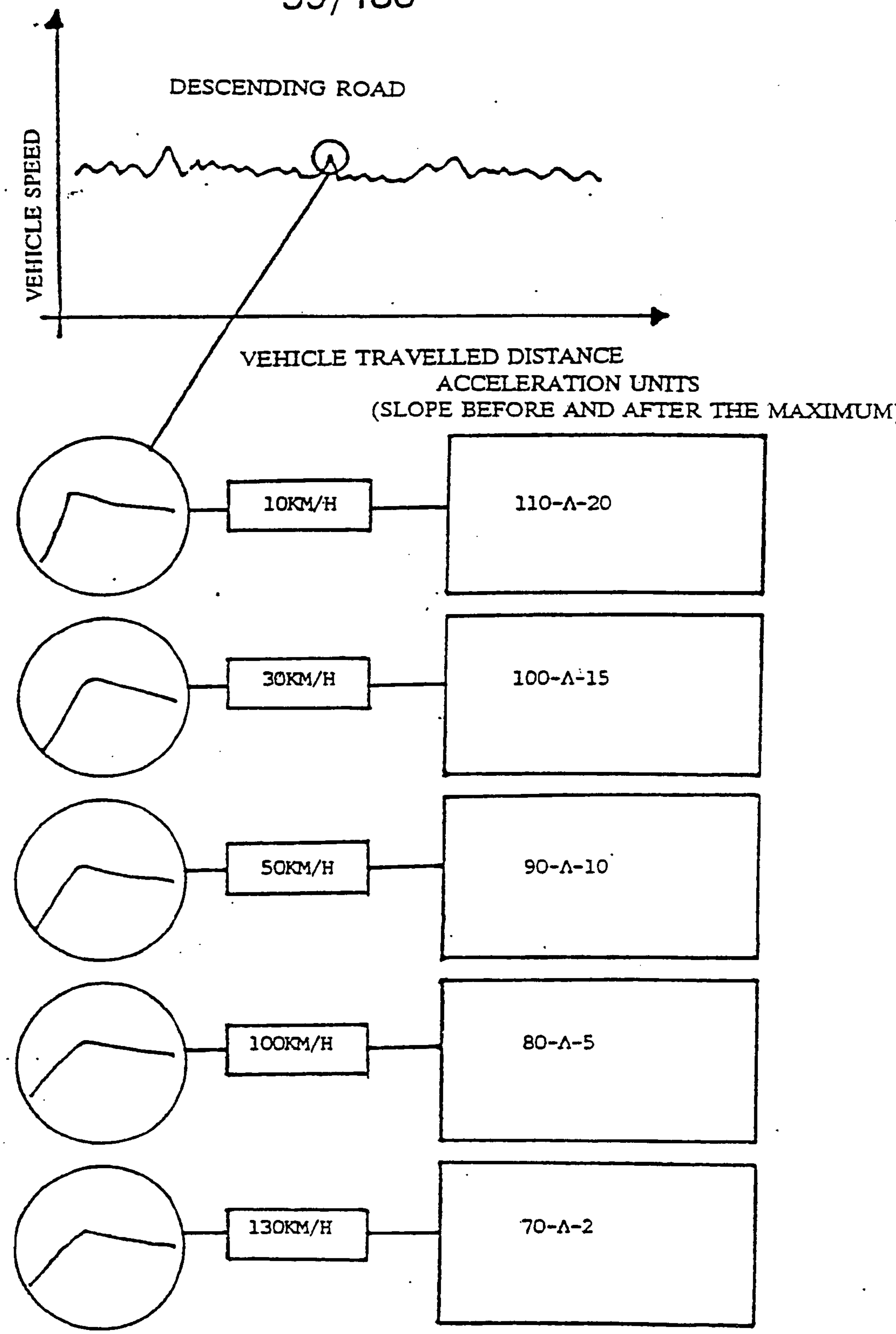

ASCENDING ROAD
VEHICLE SPEED
VEHICLE TRAVELLED DISTANCE
ACCELERATION UNITS
(SLOPE BEFORE AND AFTER THE MAXIMUM)
10KM/H
70-Λ-100
30KM/H
60-Λ-90
50KM/H
50-Λ-80
100KM/H
40-Λ-70
130KM/H
30-Λ-60

FIGURE 93



DESCENDING ROAD
VEHICLE SPEED
VEHICLE TRAVELLED DISTANCE
ACCELERATION UNITS
(SLOPE BEFORE AND AFTER THE MAXIMUM)
10KM/H
110-Λ-20
30KM/H
100-Λ-15
50KM/H
90-Λ-10
100KM/H
80-Λ-5
130KM/H
70-Λ-2

FIGURE 94

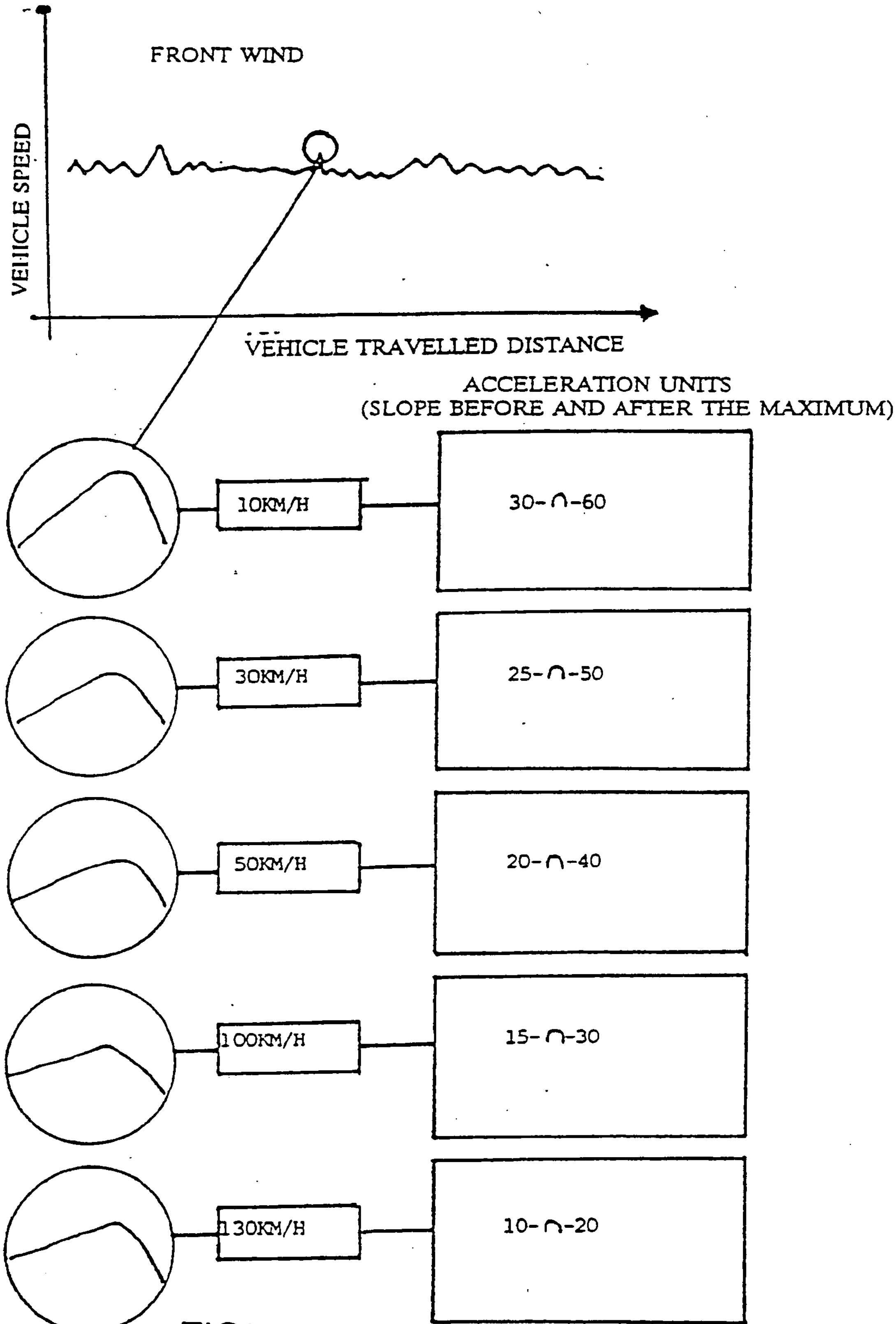

FRONT WIND
VEHICLE SPEED
VEHICLE TRAVELLED DISTANCE
ACCELERATION UNITS
(SLOPE BEFORE AND AFTER THE MAXIMUM)
10KM/H
30-∩-60
30KM/H
25-∩-50
50KM/H
20-∩-40
100KM/H
15-∩-30
130KM/H
10-∩-20

FIGURE 95

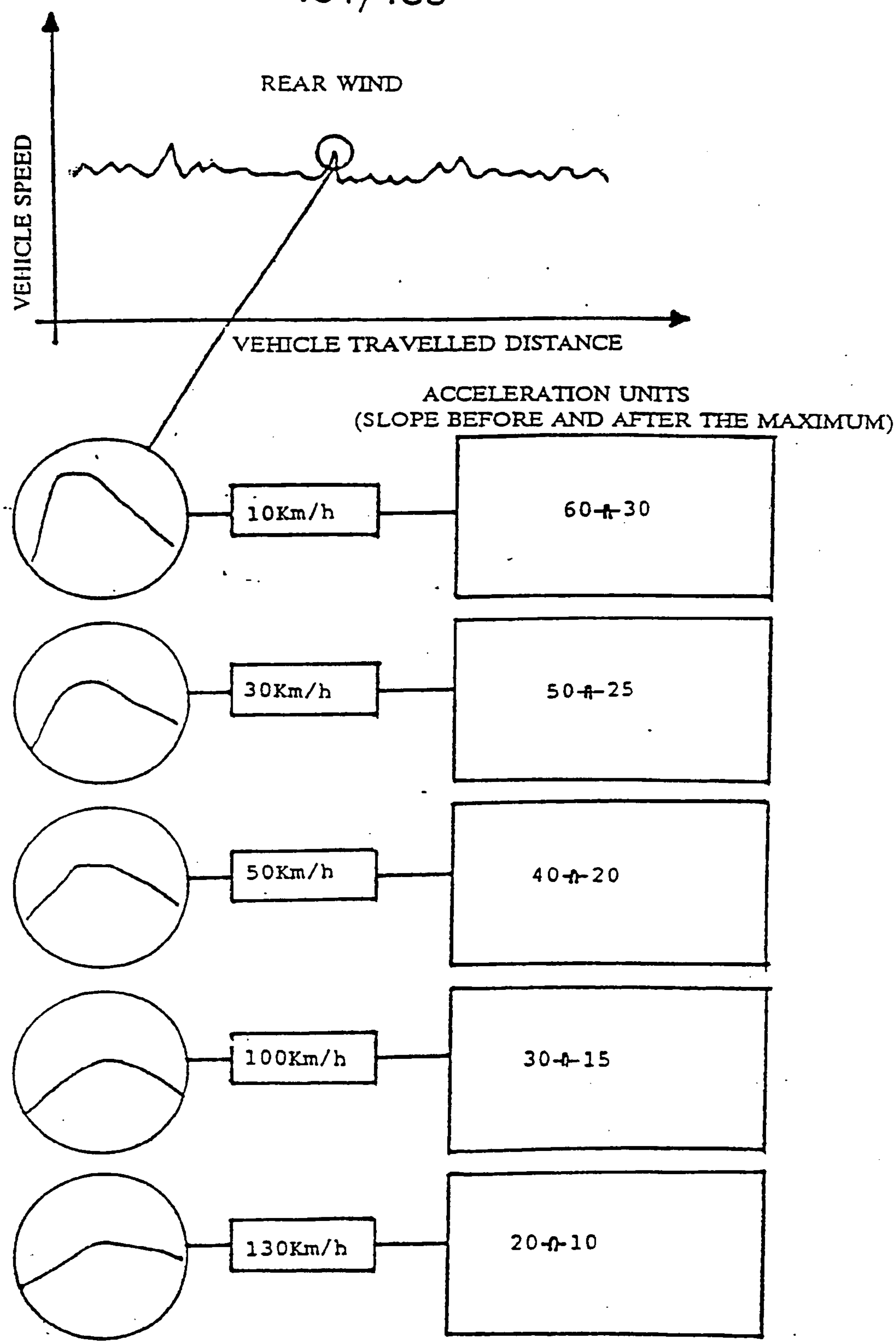

REAR WIND
VEHICLE SPEED
VEHICLE TRAVELLED DISTANCE
ACCELERATION UNITS
(SLOPE BEFORE AND AFTER THE MAXIMUM)
10Km/h
60-⋂-30
30Km/h
50-⋂-25
50Km/h
40-⋂-20
100Km/h
30-⋂-15
130Km/h
20-⋂-10

FIGURE 96

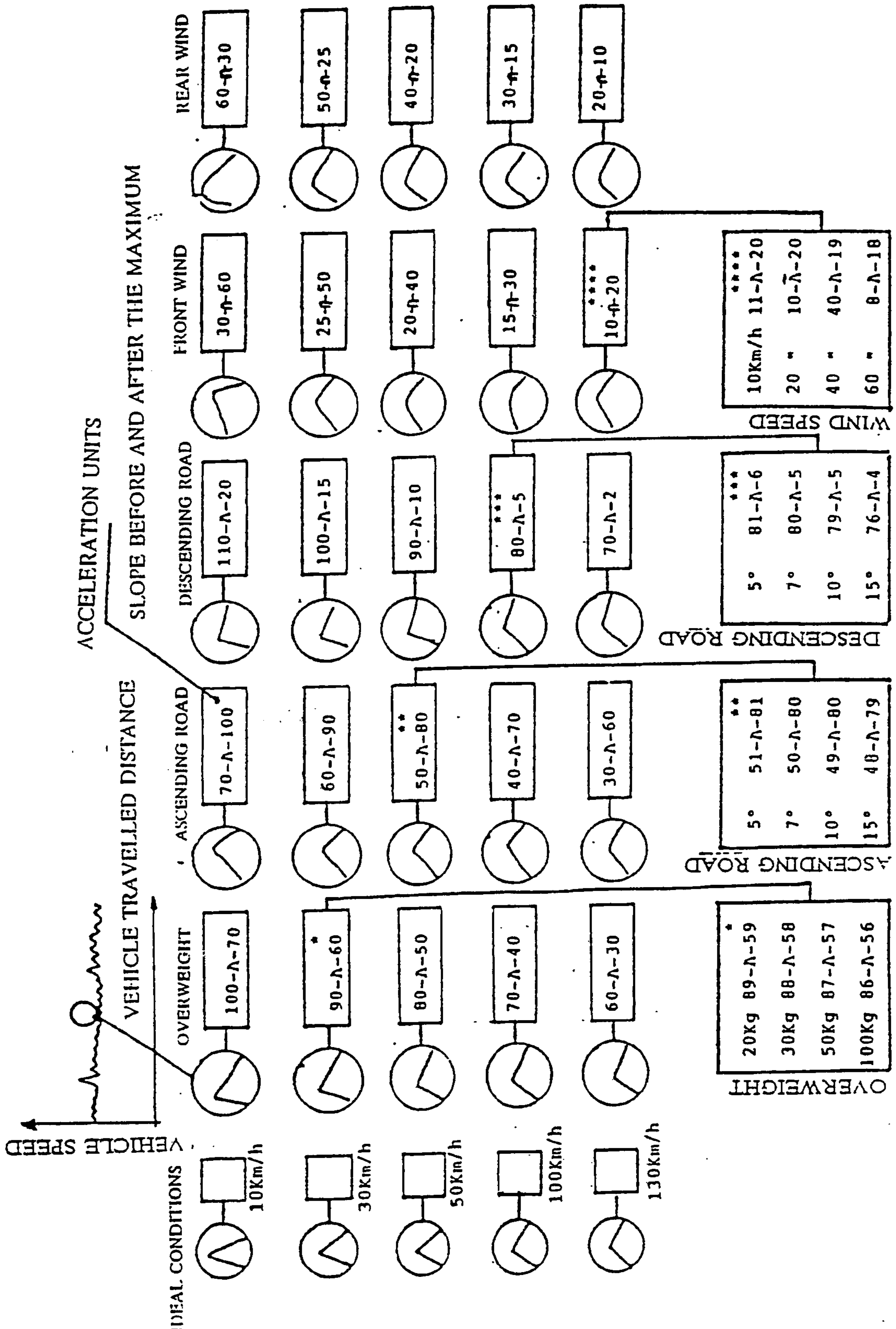

IDEAL CONDITIONS
10Km/h
30Km/h
50Km/h
100Km/h
130Km/h
VEHICLE SPEED
VEHICLE TRAVELLED DISTANCE
ACCELERATION UNITS
SLOPE BEFORE AND AFTER THE MAXIMUM
OVERWEIGHT
100-Λ-70
90-Λ-60 *
80-Λ-50
70-Λ-40
60-Λ-30
ASCENDING ROAD
70-Λ-100
60-Λ-90
50-Λ-80 **
40-Λ-70
30-Λ-60
DESCENDING ROAD
110-Λ-20
100-Λ-15
90-Λ-10
80-Λ-5 ***
70-Λ-2
FRONT WIND
30-Λ-60
25-Λ-50
20-Λ-40
15-Λ-30
10-Λ-20 ****
REAR WIND
60-Λ-30
50-Λ-25
40-Λ-20
30-Λ-15
20-Λ-10
OVERWEIGHT
20Kg 89-Λ-59 *
30Kg 88-Λ-58
50Kg 87-Λ-57
100Kg 86-Λ-56
ASCENDING ROAD
5° 51-Λ-81 **
7° 50-Λ-80
10° 49-Λ-80
15° 48-Λ-79
DESCENDING ROAD
5° 81-Λ-6 ***
7° 80-Λ-5
10° 79-Λ-5
15° 76-Λ-4
WIND SPEED
10Km/h 11-Λ-20 ****
20 " 10-Λ-20
40 " 40-Λ-19
60 " 8-Λ-18

FIGURE 97

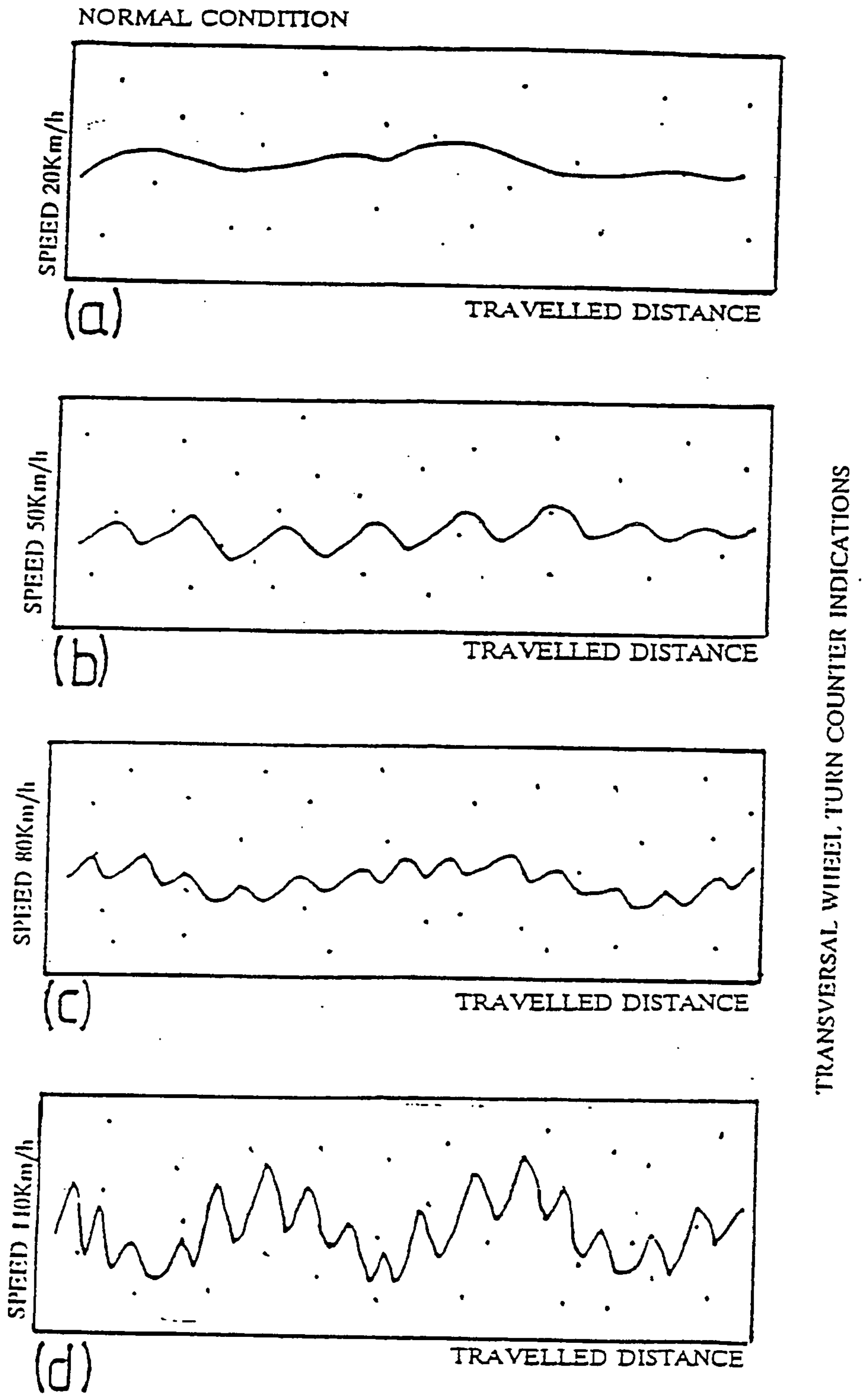

NORMAL CONDITION
SPEED 20Km/h
(a)
TRAVELLED DISTANCE
SPEED 50Km/h
(b)
TRAVELLED DISTANCE
SPEED 80Km/h
(c)
TRAVELLED DISTANCE
SPEED 110Km/h
(d)
TRAVELLED DISTANCE
TRANSVERSAL WHEEL TURN COUNTER INDICATIONS

FIGURE 98

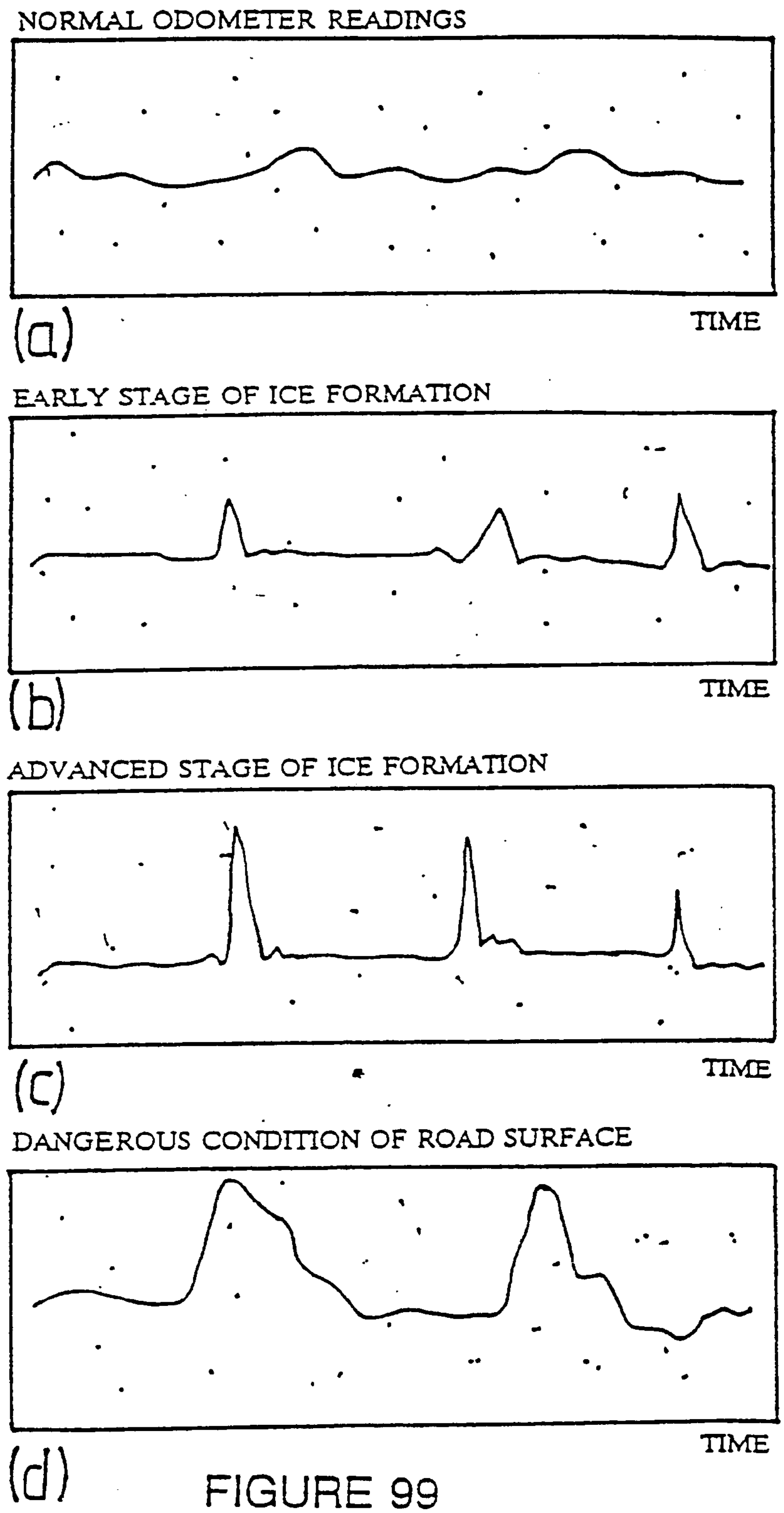

NORMAL ODOMETER READINGS
(a)
TIME
EARLY STAGE OF ICE FORMATION
(b)
TIME
ADVANCED STAGE OF ICE FORMATION
(c)
TIME
DANGEROUS CONDITION OF ROAD SURFACE
(d)
TIME

FIGURE 99

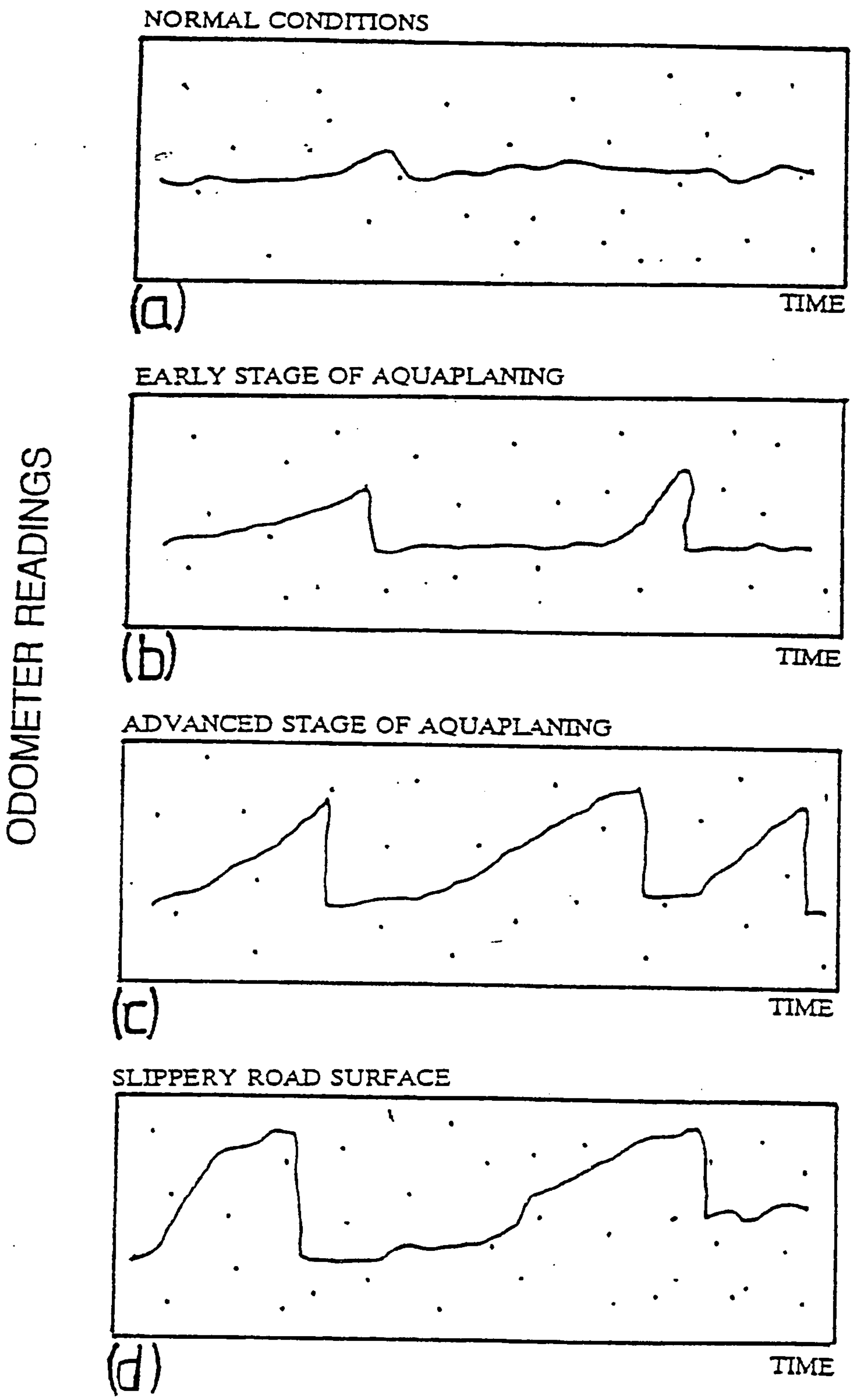

ODOMETER READINGS
NORMAL CONDITIONS
(a)
TIME
EARLY STAGE OF AQUAPLANING
(b)
TIME
ADVANCED STAGE OF AQUAPLANING
(c)
TIME
SLIPPERY ROAD SURFACE
(d)
TIME

FIGURE 100

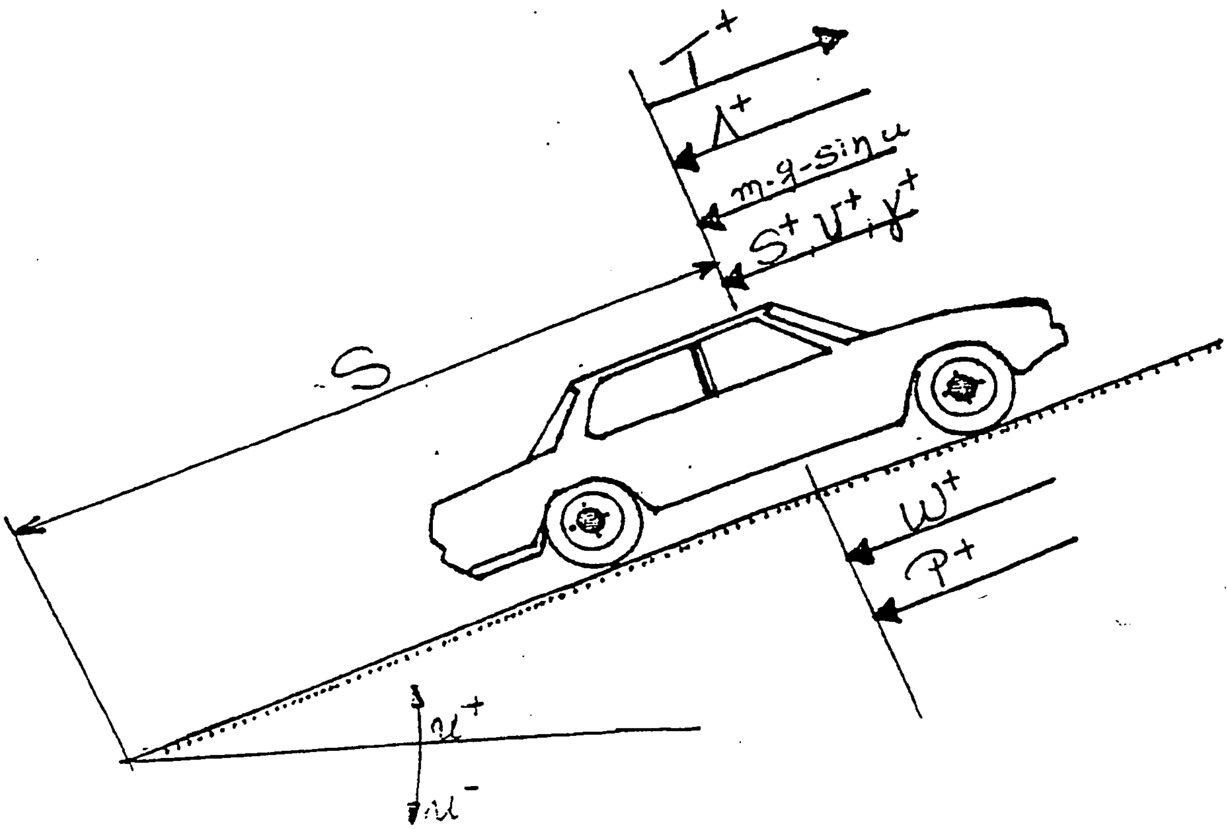


FIGURE 101

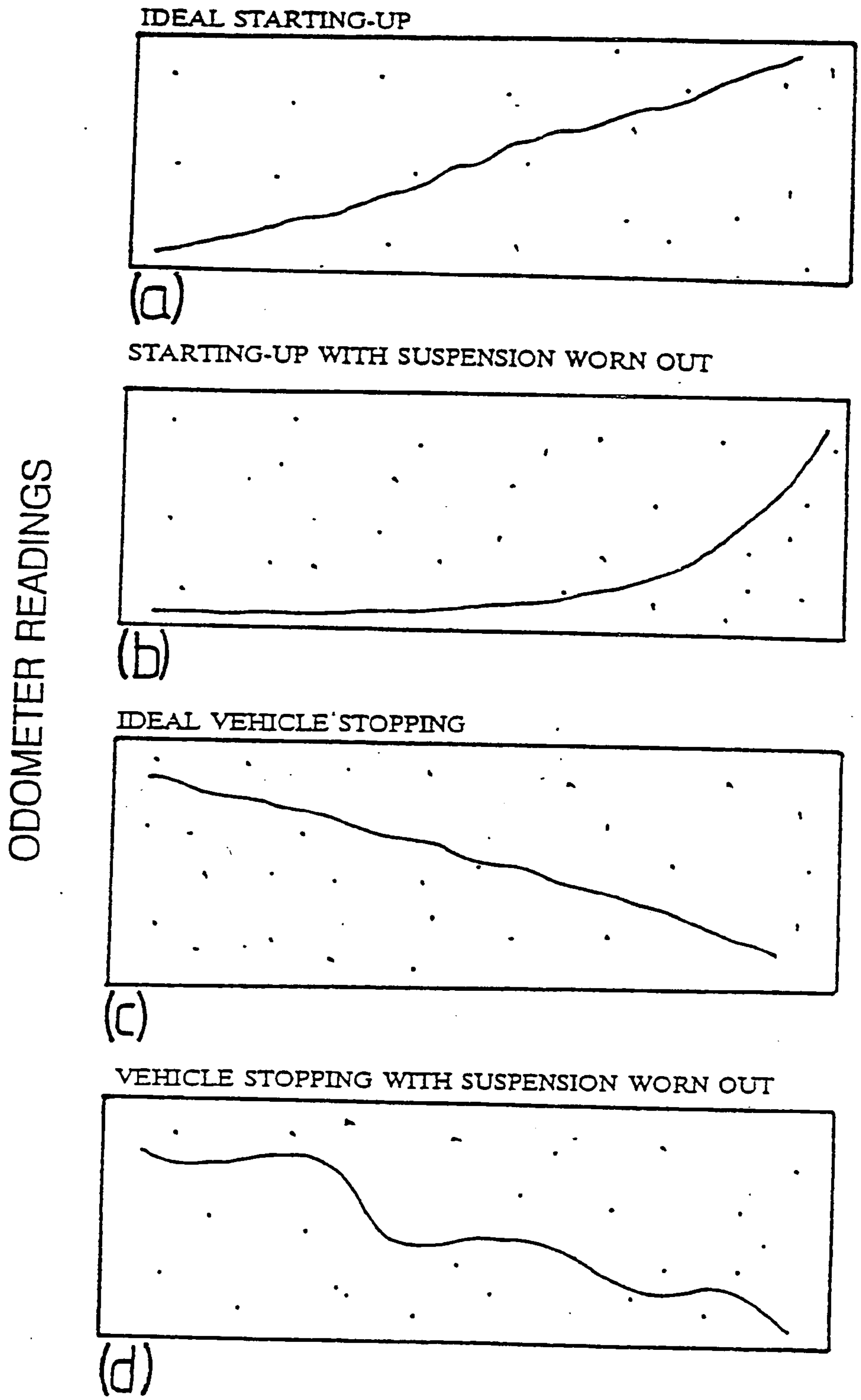

IDEAL STARTING-UP
(a)
STARTING-UP WITH SUSPENSION WORN OUT
(b)
IDEAL VEHICLE STOPPING
(c)
VEHICLE STOPPING WITH SUSPENSION WORN OUT
(d)
ODOMETER READINGS

FIGURE 102

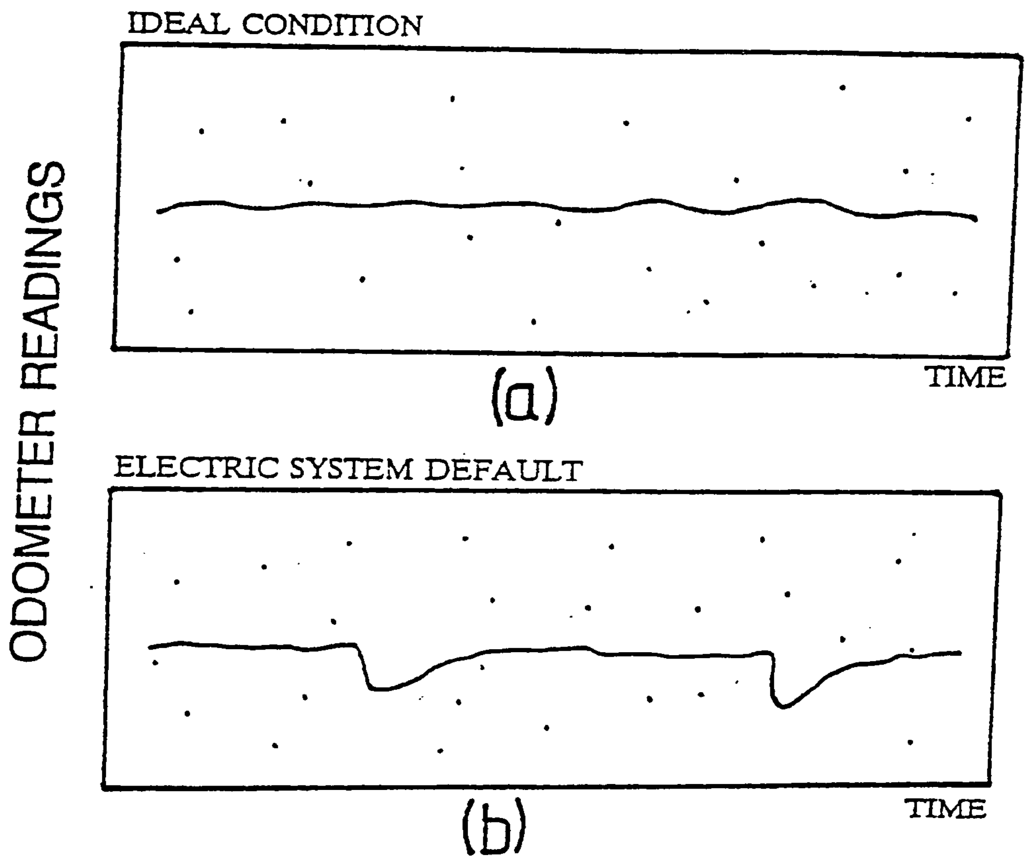

IDEAL CONDITION
ODOMETER READINGS
TIME
(a)
ELECTRIC SYSTEM DEFAULT
TIME
(b)

FIGURE 103

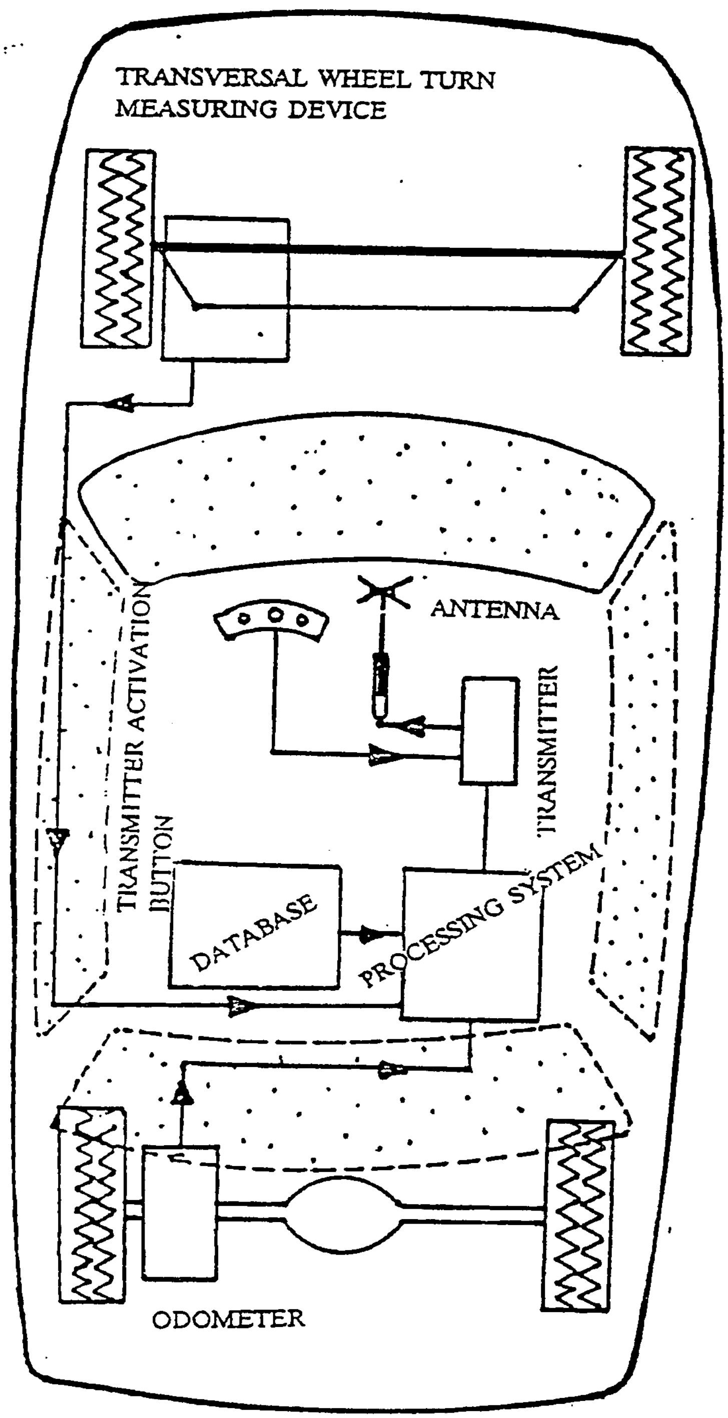

TRANSVERSAL WHEEL TURN
MEASURING DEVICE
ANTENNA
TRANSMITTER ACTIVATION
BUTTON
TRANSMITTER
DATABASE
PROCESSING SYSTEM
ODOMETER

FIGURE 104

TYPE OF ACCIDENT	DEADLY	+	BELL	COFFIN	A1
	HEAVY INJURIES	T	SIREN	RED CROSS	A2
	LIGHT INJURIES	E	PHONE RINGING	BLUE CROSS	A3
	MATERIAL DAMAGES	L	HAMMER SLAM	HAMMER	A4
TYPE OF VEHICLE	PASSENGER VEHICLE	O-O	SI (note)	PASSENGER VEHICLE IMAGE	B1
	TRUCK	O‾O	SOL	TRUCK IMAGE	B2
	BUS	O'O	FA	BUS IMAGE	B3
	TOWED VEHICLE	O--O--O	DO	TOWED VEHICLE IMAGE	B4
CAUSE OF ACCIDENT	EXCESSIVE SPEED	ł	WHISTLE	SPEED COUNTER	C1
	ILLEGAL OVER-TAKING	4	WHISTLE & DO	2 VEHICLES (BLACK & RED)	C2
	VIOLATION OF TRAFFIC SIGN OR LIGHT	8	GLASS BREAKING	TRAFFIC LIGHT	C3
	DRIVER'S BAD CONDITION		DO-SI-DO-SI	DRIVER'S FIGURE	C4
	OTHER	*	NEUTRAL SOUND	DEPENDING ON THE CAUSE	C5
TIME OF OCCURENCE	SEASON: AUTOMN, SPRING, WINTER	I,II,III,IV	COUNTING	LATIN NUMBER SEASON	D1
	MONTH 1-12	1,2,3...12	COUNTING	ARABIAN NUMBER	D2
	MORNING, NOON, AFTERNOON, EVENING, NIGHT	A, B, C, D, E	LETTERS	A LETTER	D3
WEATHER CONDITIONS	RAIN	| | |	SOUND OF RAIN	E1	
	FOG		MI-DO	FIGURE OF CLOUD	E2
	ICE	+	DO-DO	oooooo oooooooo oooooo	E1
	WIND	--> -->	SOUND OF WIND	->->-> ->->->	E4
REMARKS	ROAD SHAPING	S	SOUND OF ENGINE	FIGURE OF ROAD	Z1
	DRIVERS' ATTITUDE		SHOT	DRIVER'S FIGURE	Z2
	SEASONAL OR LOCAL EVENTS	Ψ	SAXO-PHONE	FIREWORK	Z3

FIGURE 105

F-354 Starting point code

S-658 Exit code

350 Length of routing

100	TOUCH SIGN	SOUND	IMAGE	DISTANCE FROM STARTING POINT
A1	+	BELL	COFFIN	KIND OF ACCIDENT
B1	O–O	SI	PASSENGER VEHICLE IMAGE	TYPE OF VEHICLE
C1		WHISTLE	SPEED COUNTER	CAUSE OF ACCIDENT
D1, D2, D3	II, 10, 6	TWO, TEN, E	II, 10, E	DETERMINA-TION OF TIME
E1	|||	SOUND OF RAIN		WEATHER CONDITIONS
Z1	S	SOUND OF MOTOR	ROAD FIGURE	REMARKS
150	TOUCH SIGN	SOUND	IMAGE	DISTANCE FROM STARTING POINT
A2	T	SIRENE	RED CROSS	KIND OF ACCIDENT
B3	O''O	FA	BUS IMAGE	KIND OF ACCIDENT
C2	4	WHISTLE-DO	TWO VEHICLES BLACK & RED	CAUSE OF ACCIDENT
D1, D2, D3	I, 3, B	ONE, THREE, B	I, 3, B	DETERMINA-TION OF TIME
E2		MI, DO	CLOUD FIGURE	WEATHER CONDITIONS
Z1	S	SOUND OF ENGINE	ROAD FIGURE	REMARKS
230	TOUCH SIGN	SOUND	IMAGE	DISTANCE FROM STARTING POINT
A4	L	HAMMER SLAM	HAMMER	KIND OF ACCIDENT
B4	O-O-O	DO	TOWED VEHICLE IMAGE	TYPE OF VEHICLE
C4		DO-SI, DO-SI	HUMAN FIGURE	CAUSE OF ACCIDENT
D1, D2, D3	III, 5, C	THREE, FIVE, C	III, 5, C	DETERMINA-TION OF TIME
E3	♦	DO-DO		WEATHER CONDITIONS
Z3	Y	SAXOPHONE	FIREWORK	REMARKS

FIGURE 106

F-354	STARTING POINT CODE
S-658	EXIT CODE
550	LENGTH OF ROUTING

8	TOUCH SIGN	SOUND	IMAGE	RISK GRADE
5				NUMBER OF ACCIDENTS
A1	+	BELL	COFFIN	KIND OF ACCIDENT
8				NUMBER OF ACCIDENTS
B2	O▫O	SOL	TRUCK IMAGE	TYPE OF VEHICLE
4				NUMBER OF ACCIDENTS
C1	↑	WHISTLE	SPEED — OMETER	CAUSE OF ACCIDENT
6				NUMBER OF ACCIDENTS
D1 or D2 or D3	1, 3	ONE, THREE	1, 3	DETERMI-NATION OF TIME
5				NUMBER OF ACCIDENTS
E2	♦	DO - DO		WEATHER CONDITIONS
7				NUMBER OF ACCIDENTS
Z3	Ψ	SAXOPHONE	FIREWORK	REMARKS

FIGURE 107

TRANSMISSION	RECEPTION & ACTIONS
ABCDE (received signal code for pharmacies on night shift)	REGISTRATION IN THE ADDRESS ABCDE of the data herebelow with the following format:

TIME SPECIFIED	PART (a) - Entrance node PART (b) - Exit node PART (c) - Distance from (a)

35 - 48 - 100.4		1st pharmacy on night shift (entrance - exit nodes, distance from entrance node)
48 - 56 - 256.3		2nd pharmacy on night shift
64 - 48B - 164.8		3rd pharmacy on night shift

etc.

FIGURE 108

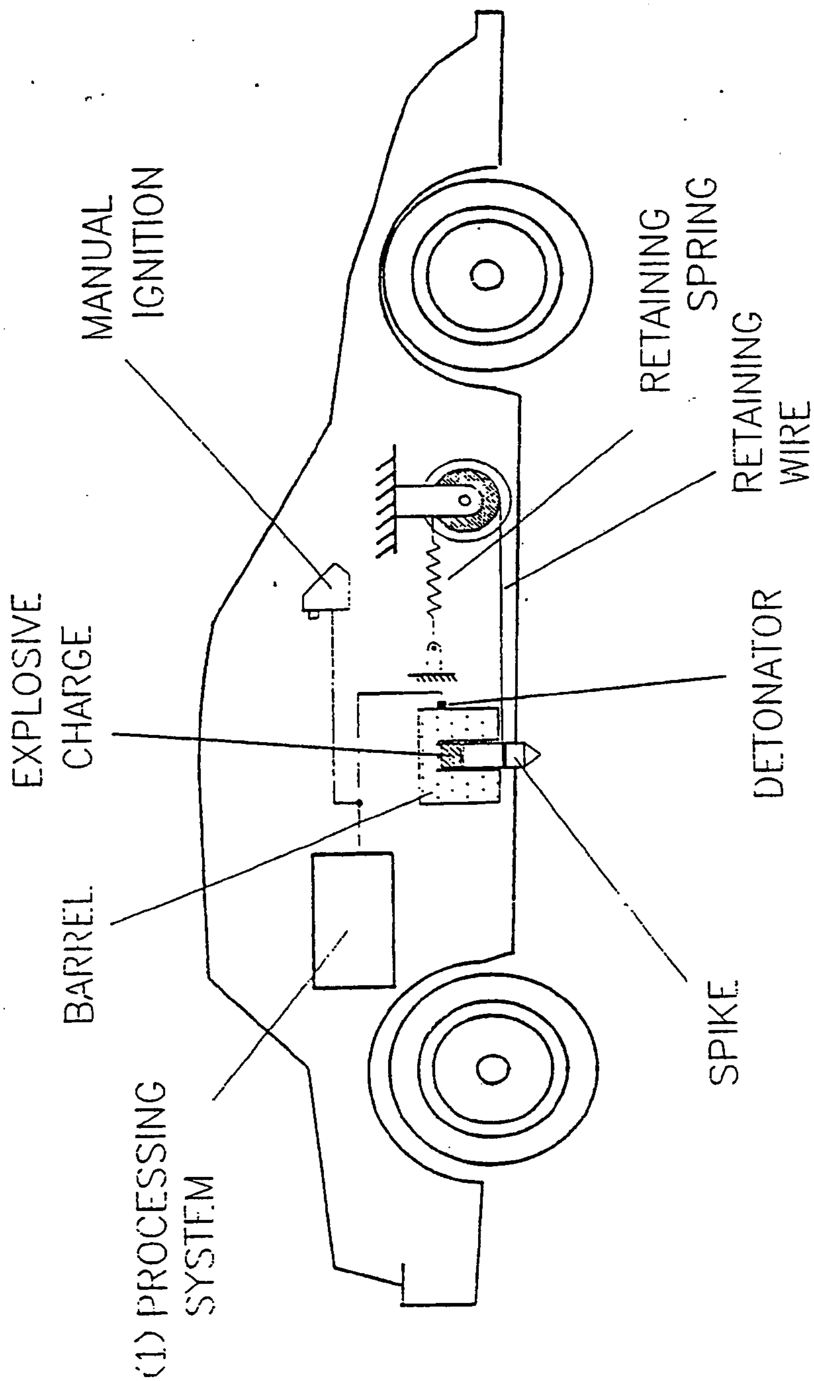

MANUAL IGNITION
RETAINING SPRING
RETAINING WIRE
EXPLOSIVE CHARGE
DETONATOR
BARREL
SPIKE
(1) PROCESSING SYSTEM

FIGURE 109

HEIGHT MEASUREMENT RULER

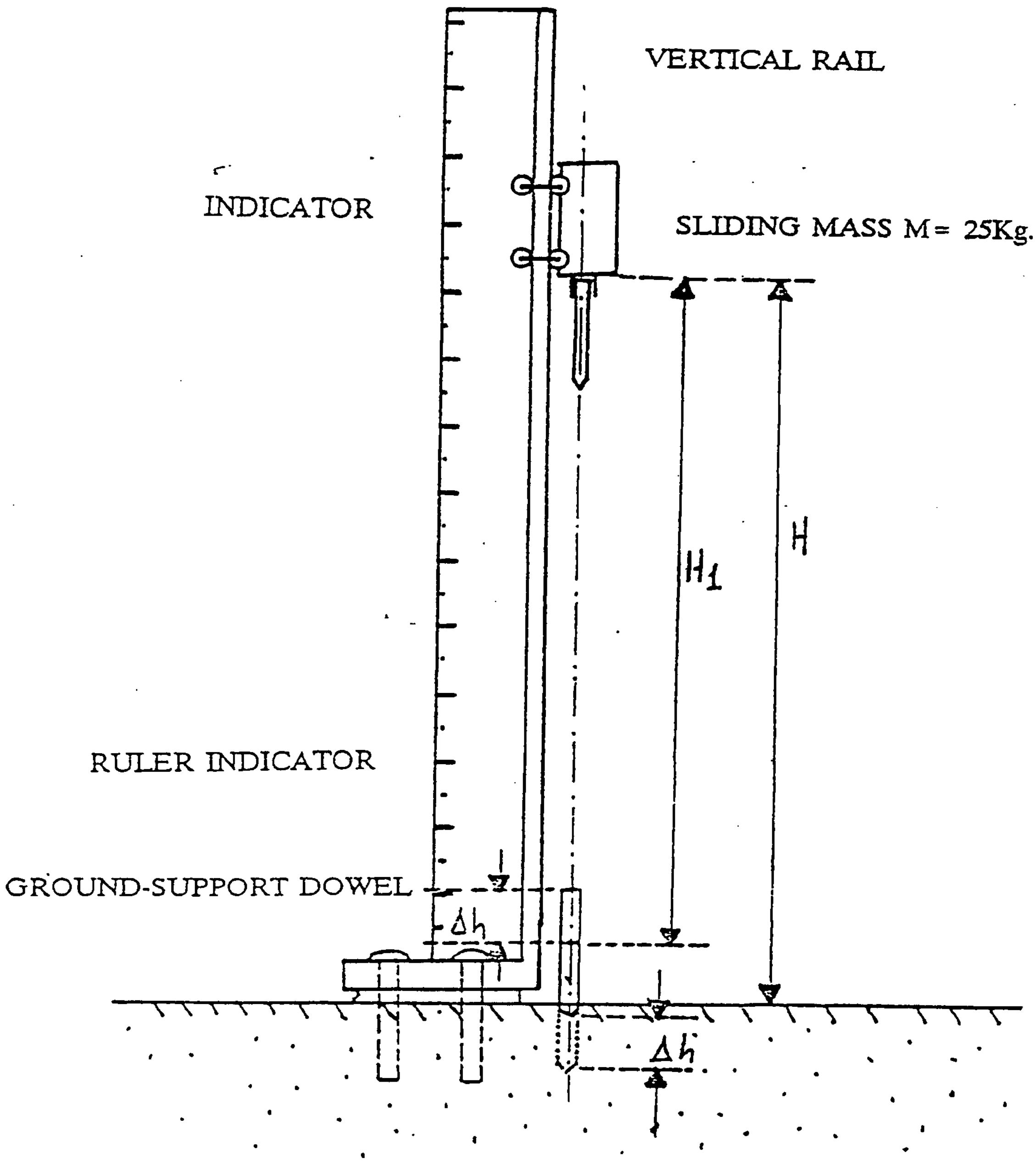


FIGURE 110

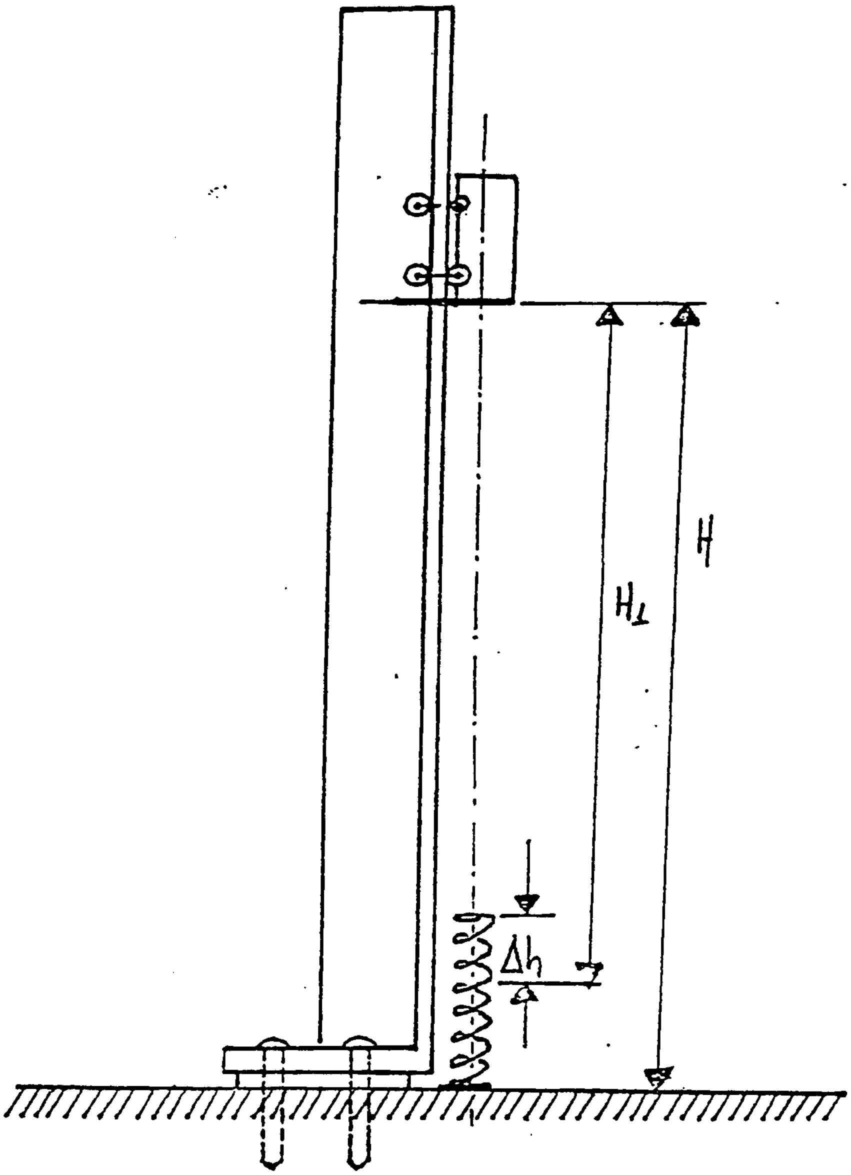


FIGURE 111

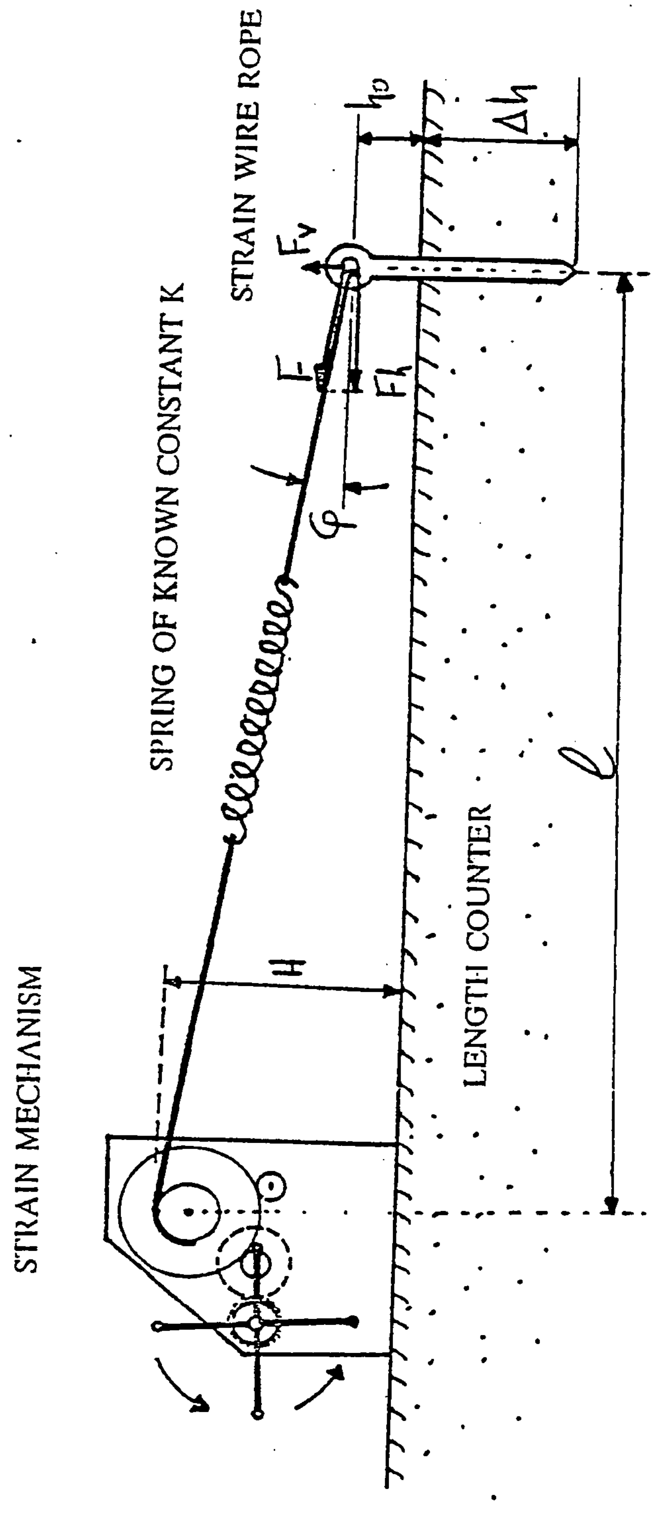

STRAIN MECHANISM
SPRING OF KNOWN CONSTANT K
STRAIN WIRE ROPE
LENGTH COUNTER
H
F_v
F
F_h
φ
h_0
Δh
ℓ

FIGURE 112

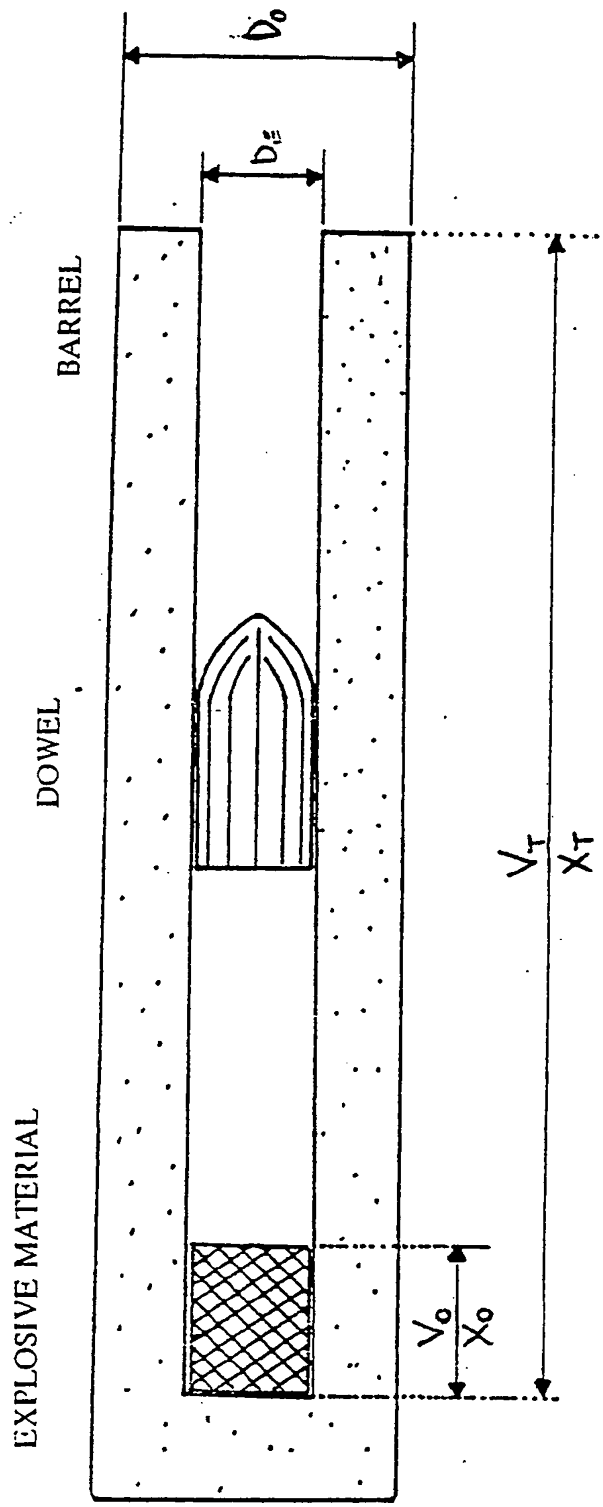


FIGURE 113

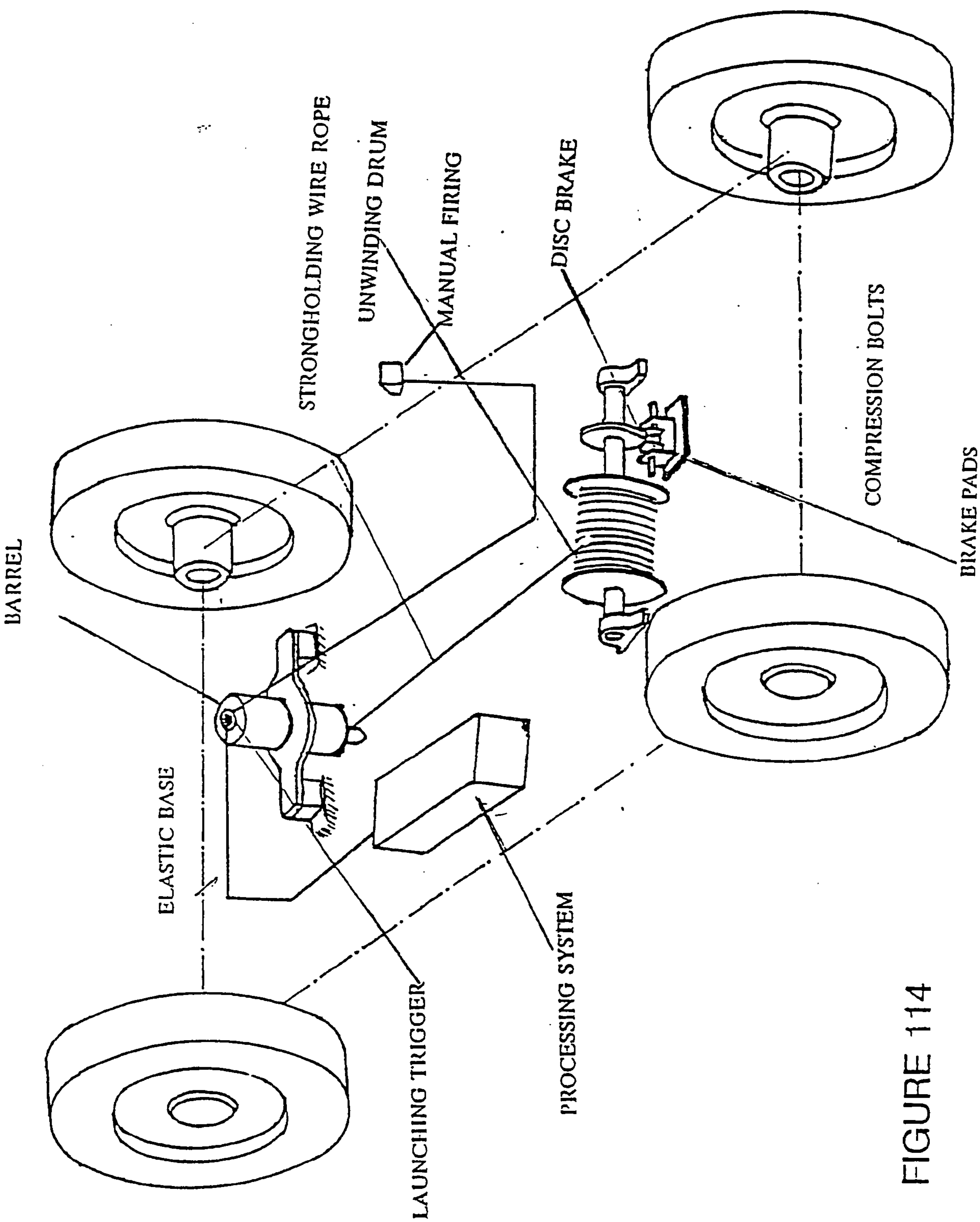

BARREL
ELASTIC BASE
LAUNCHING TRIGGER
PROCESSING SYSTEM
STRONGHOLDING WIRE ROPE
UNWINDING DRUM
MANUAL FIRING
DISC BRAKE
COMPRESSION BOLTS
BRAKE PADS

FIGURE 114

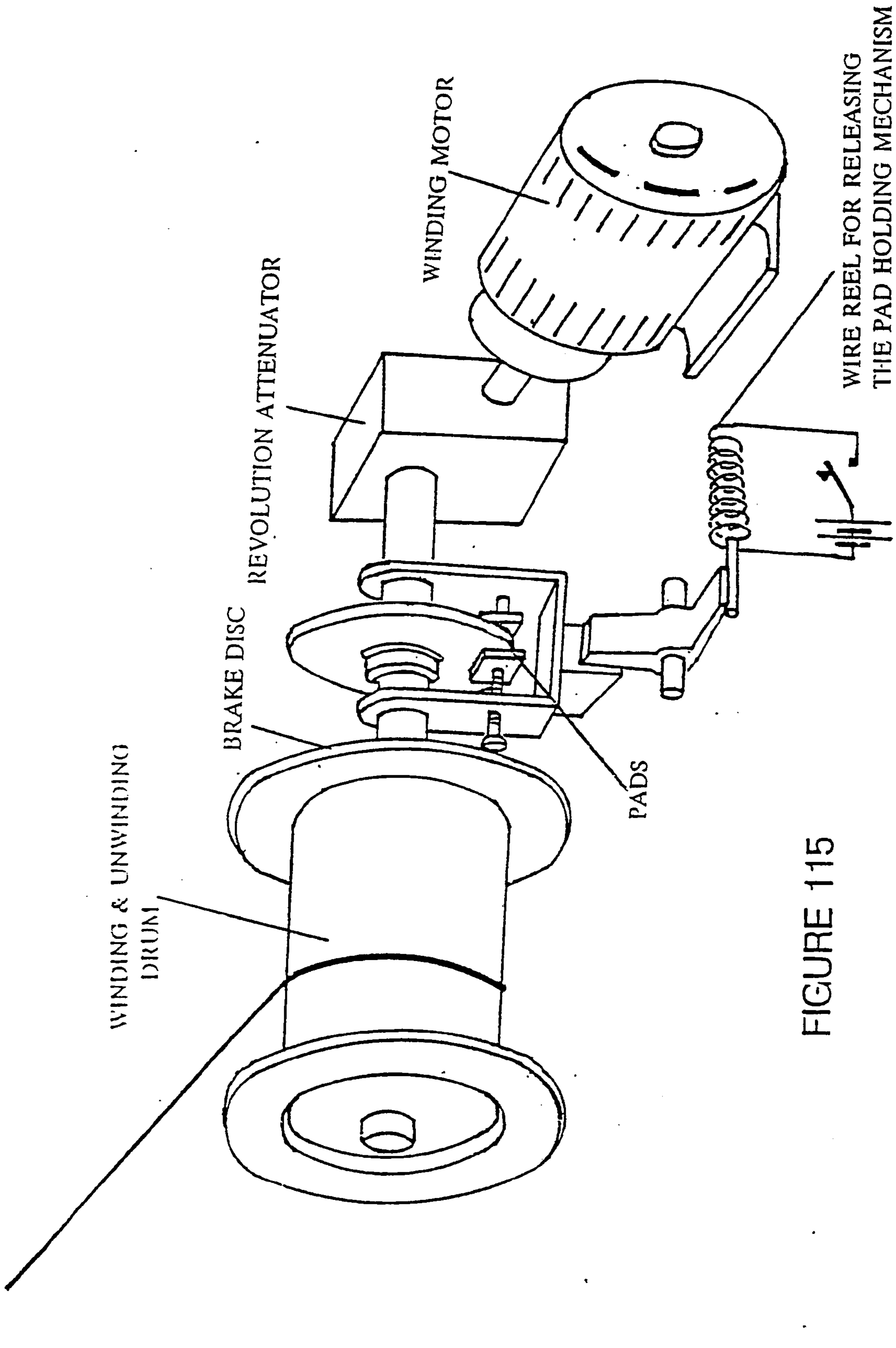

WINDING MOTOR
REVOLUTION ATTENUATOR
WIRE REEL FOR RELEASING
THE PAD HOLDING MECHANISM
BRAKE DISC
PADS
WINDING & UNWINDING
DRUM

FIGURE 115

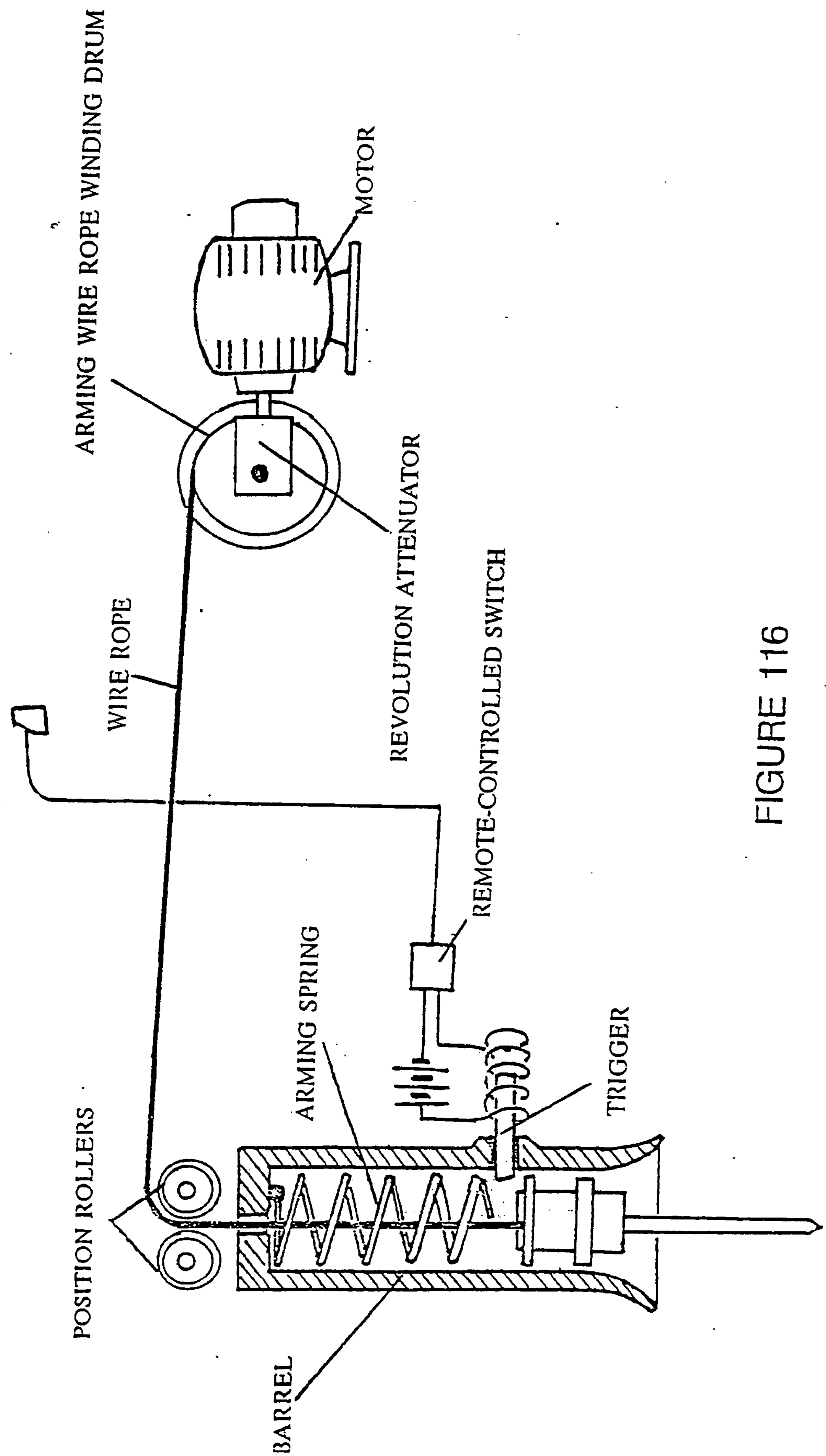

ARMING WIRE ROPE WINDING DRUM
MOTOR
REVOLUTION ATTENUATOR
WIRE ROPE
REMOTE-CONTROLLED SWITCH
ARMING SPRING
TRIGGER
POSITION ROLLERS
BARREL

FIGURE 116

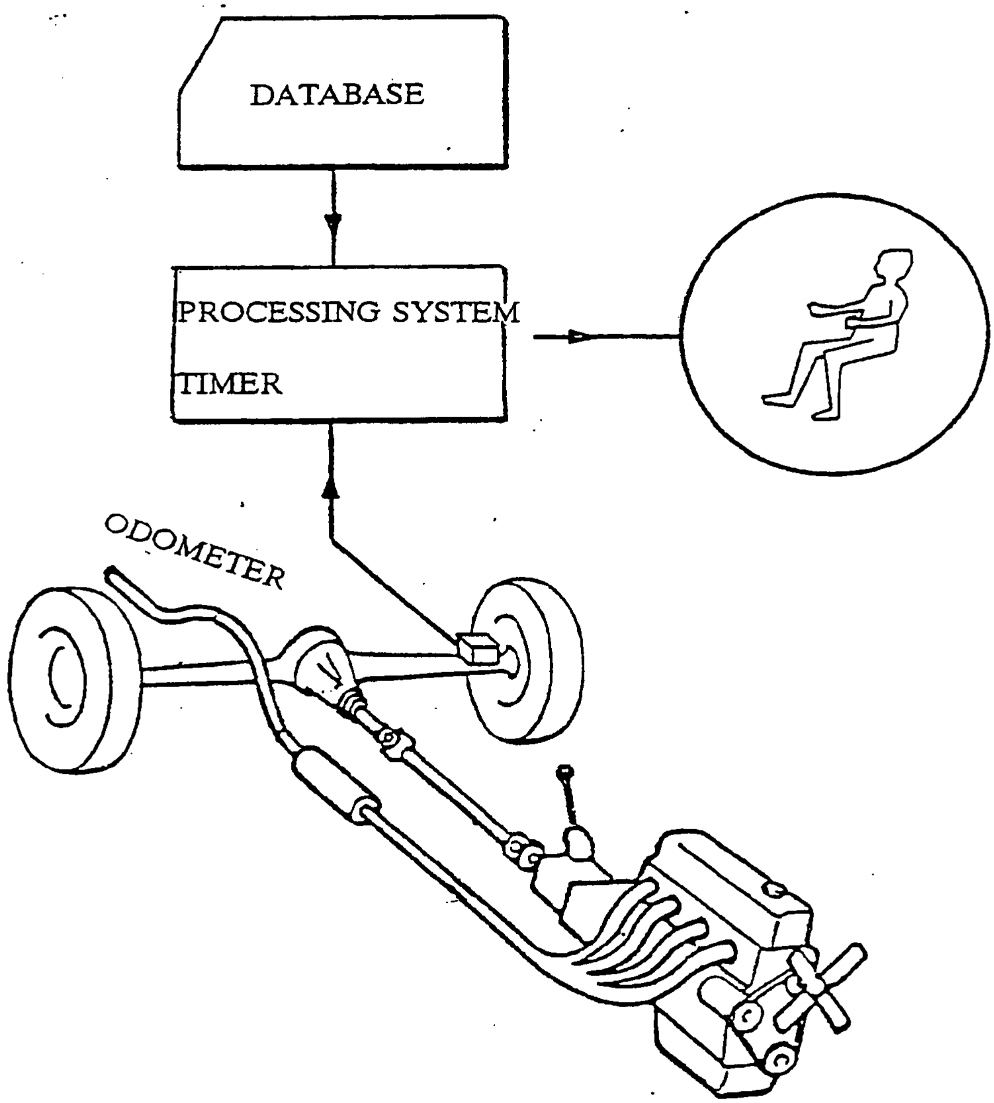


FIGURE 117

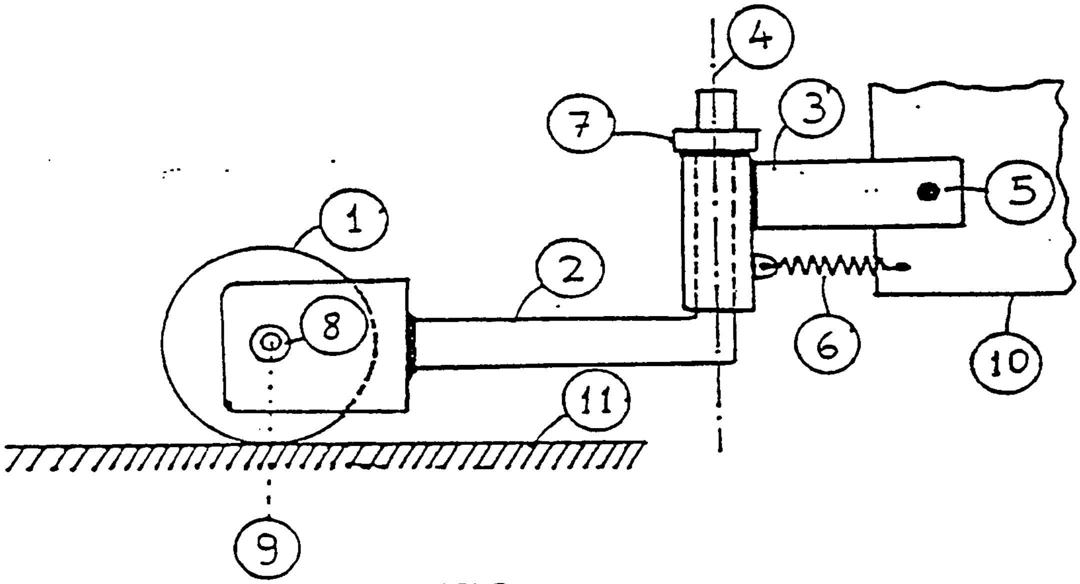


FIGURE 118

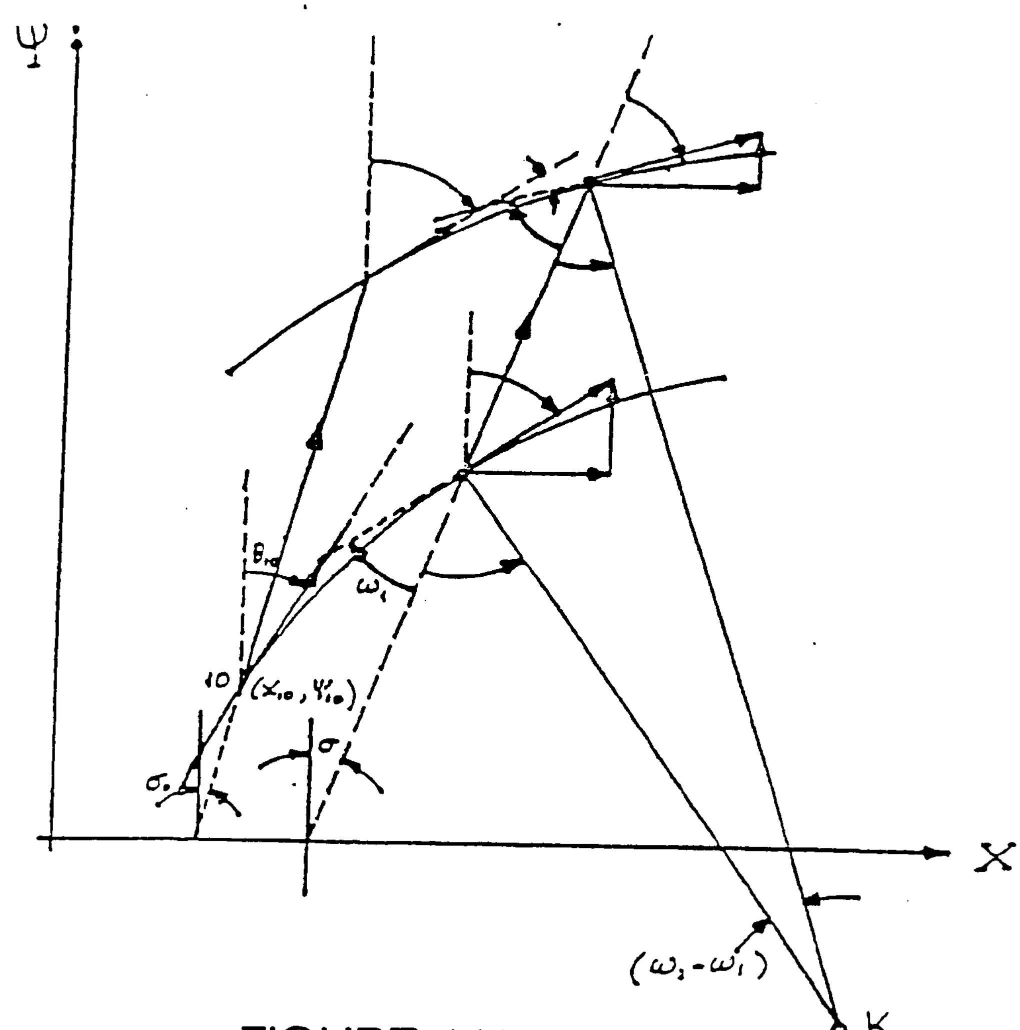


FIGURE 119

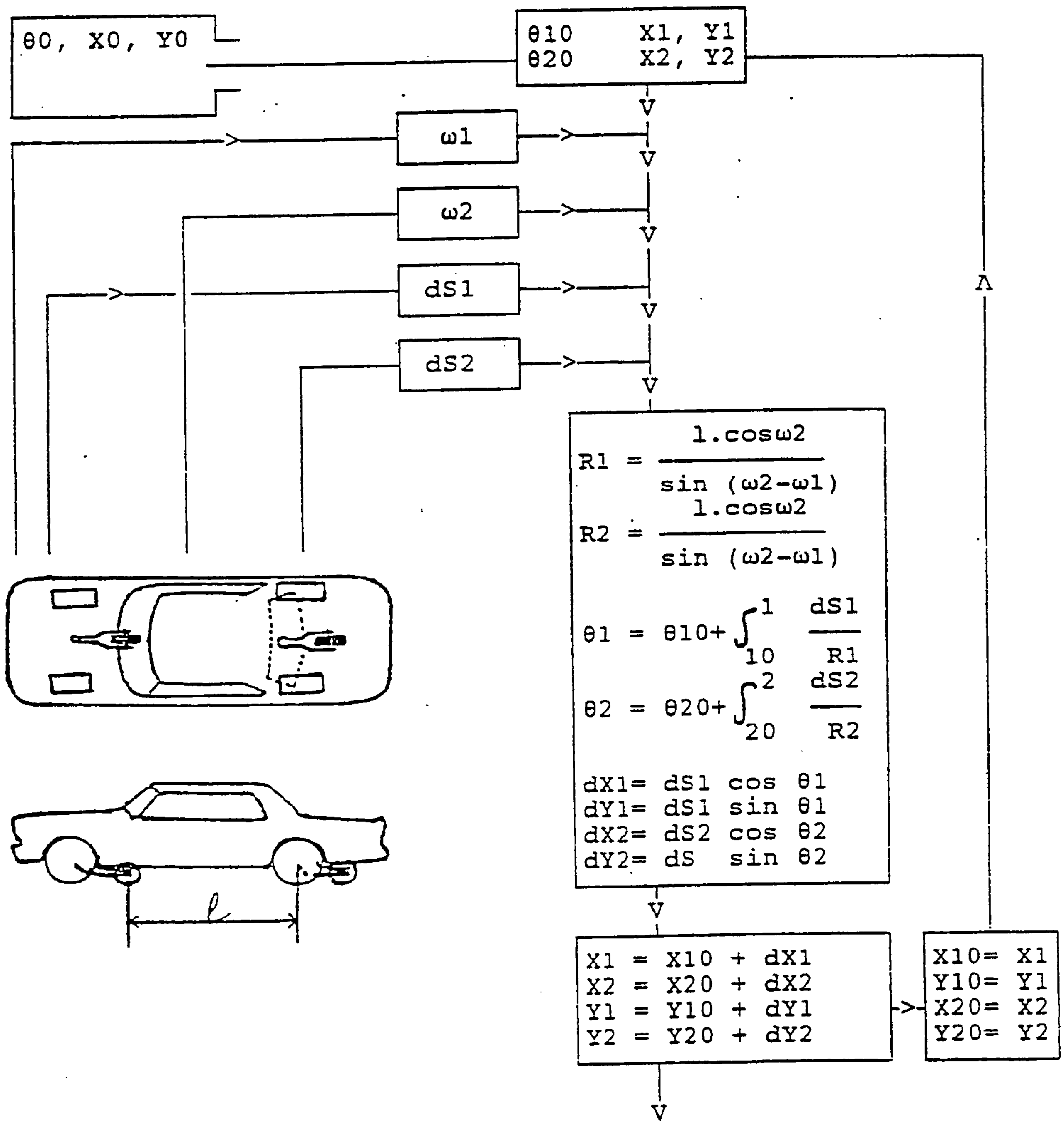

θ0, X0, Y0
θ10 X1, Y1
θ20 X2, Y2
ω1
ω2
dS1
dS2
R1 = l.cosω2 / sin (ω2-ω1)
R2 = l.cosω2 / sin (ω2-ω1)
θ1 = θ10+ ∫10 1 dS1 / R1
θ2 = θ20+ ∫20 2 dS2 / R2
dX1= dS1 cos θ1
dY1= dS1 sin θ1
dX2= dS2 cos θ2
dY2= dS sin θ2
X1 = X10 + dX1
X2 = X20 + dX2
Y1 = Y10 + dY1
Y2 = Y20 + dY2
X10= X1
Y10= Y1
X20= X2
Y20= Y2
ℓ

FIGURE 120

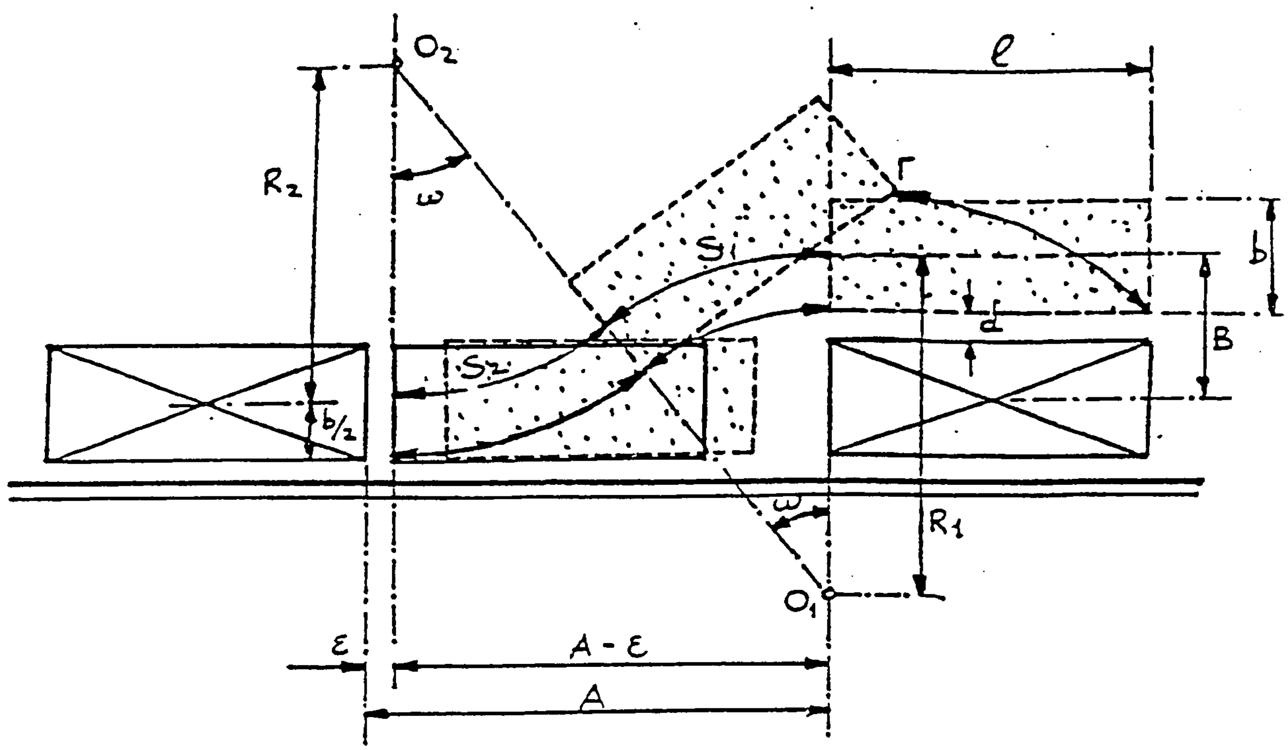


FIGURE 121

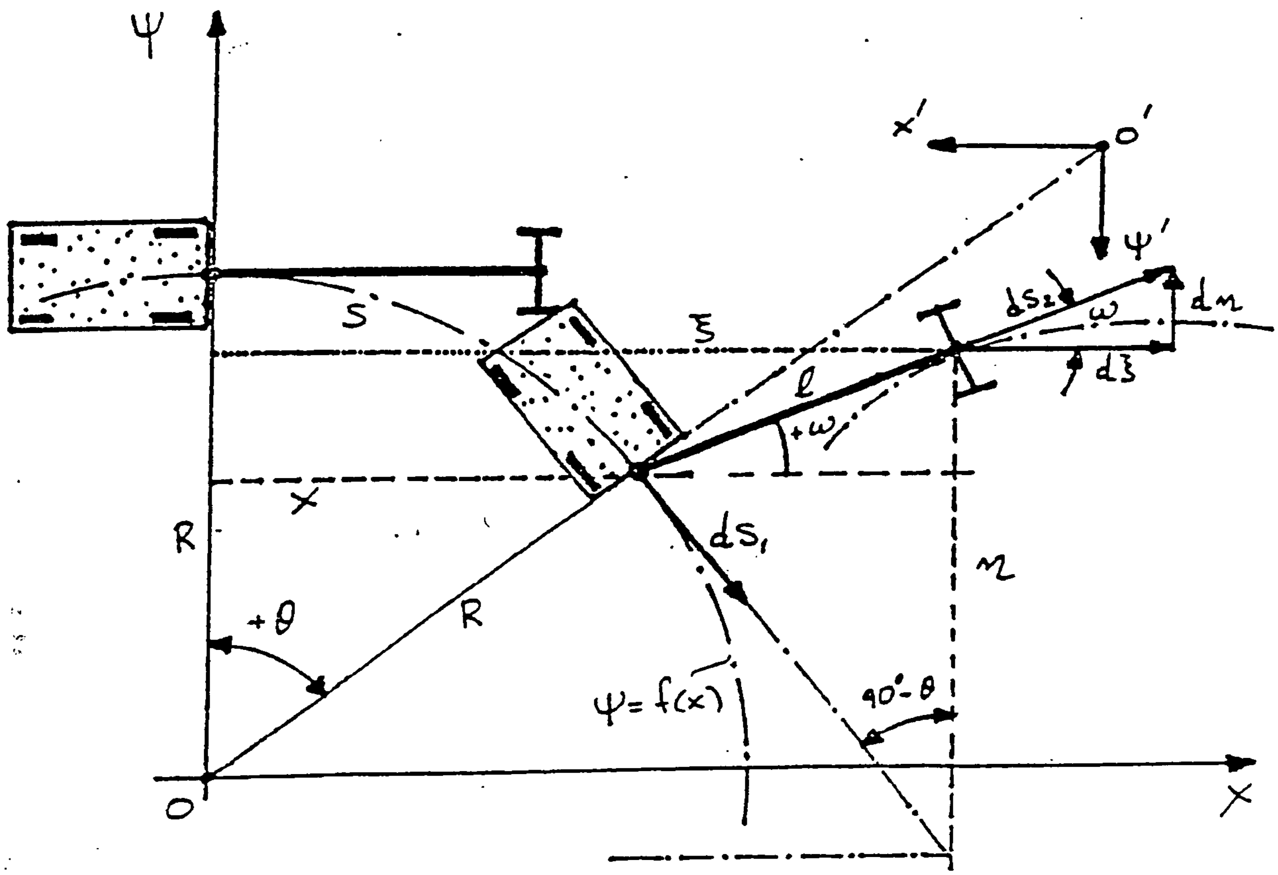


FIGURE 122

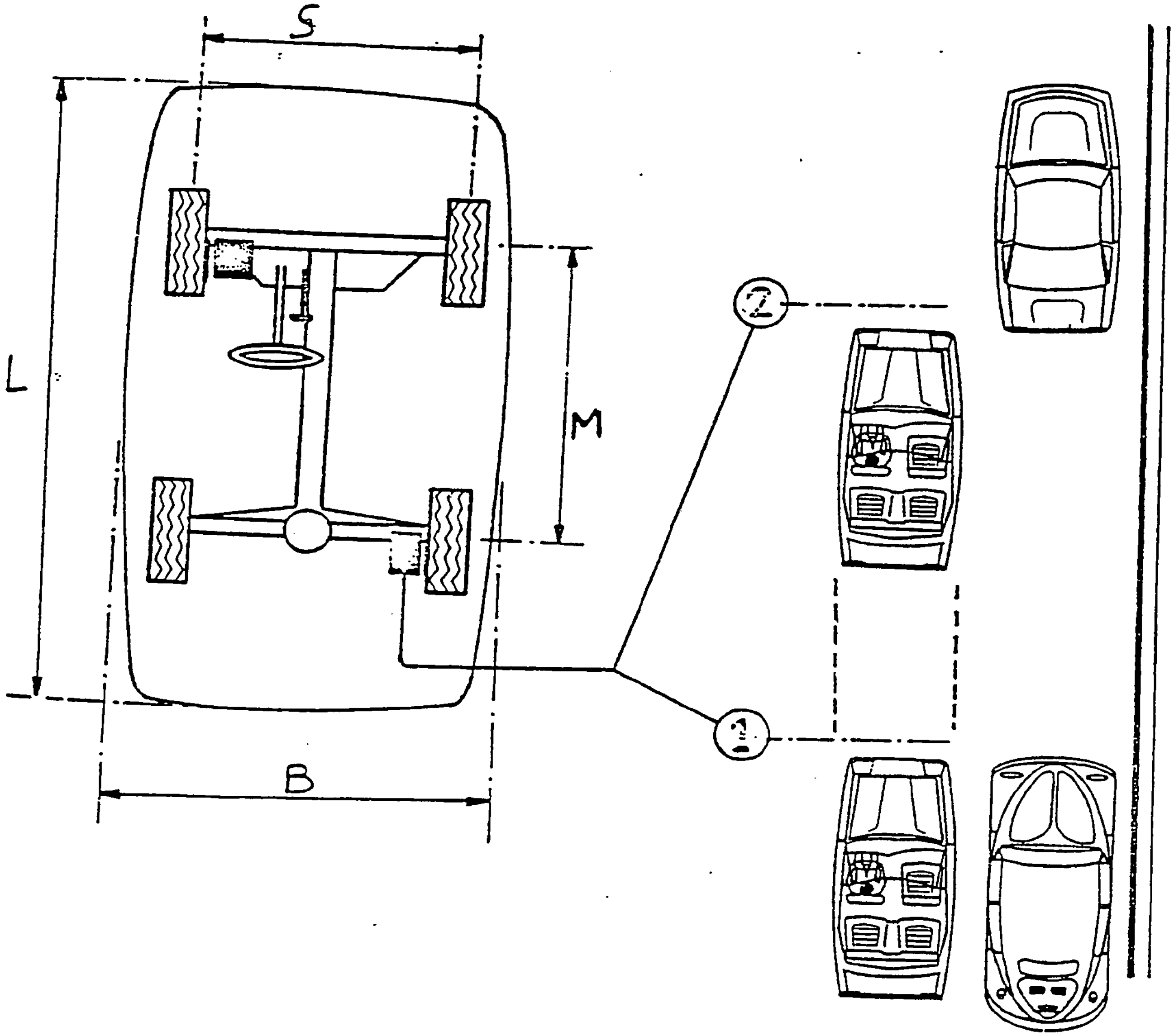


FIGURE 123

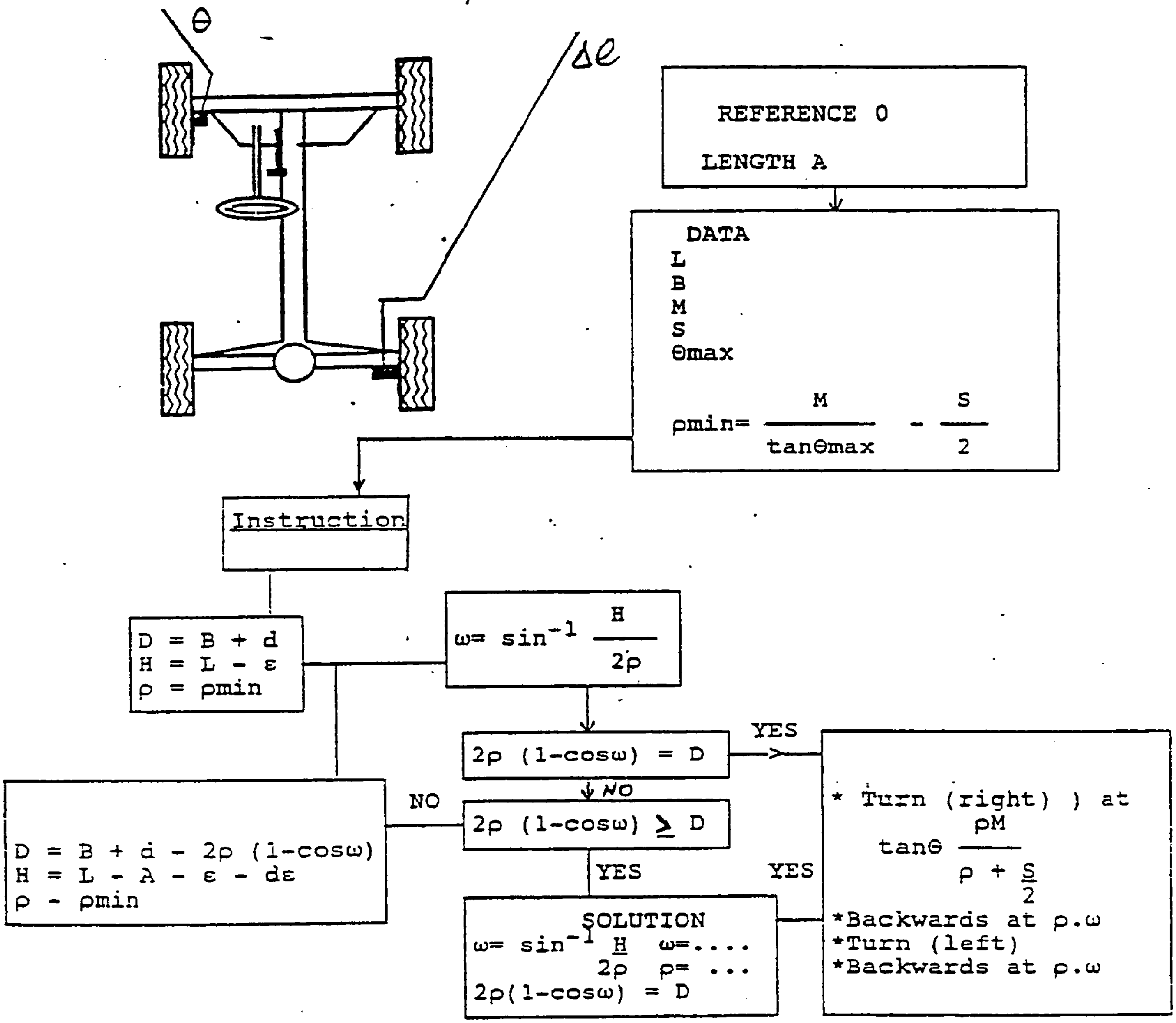

θ
Δℓ
REFERENCE 0
LENGTH A
DATA
L
B
M
S
θmax
ρmin= M / tanθmax - S / 2
Instruction
D = B + d
H = L - ε
ρ = ρmin
ω= sin⁻¹ H / 2ρ
2ρ (1-cosω) = D
YES
NO
2ρ (1-cosω) ≥ D
NO
D = B + d - 2ρ (1-cosω)
H = L - A - ε - dε
ρ - ρmin
YES
YES
SOLUTION
ω= sin⁻¹ H / 2ρ ω=....
ρ= ...
2ρ(1-cosω) = D
* Turn (right)) at
tanθ ρM / ρ + S/2
*Backwards at ρ.ω
*Turn (left)
*Backwards at ρ.ω

FIGURE 124

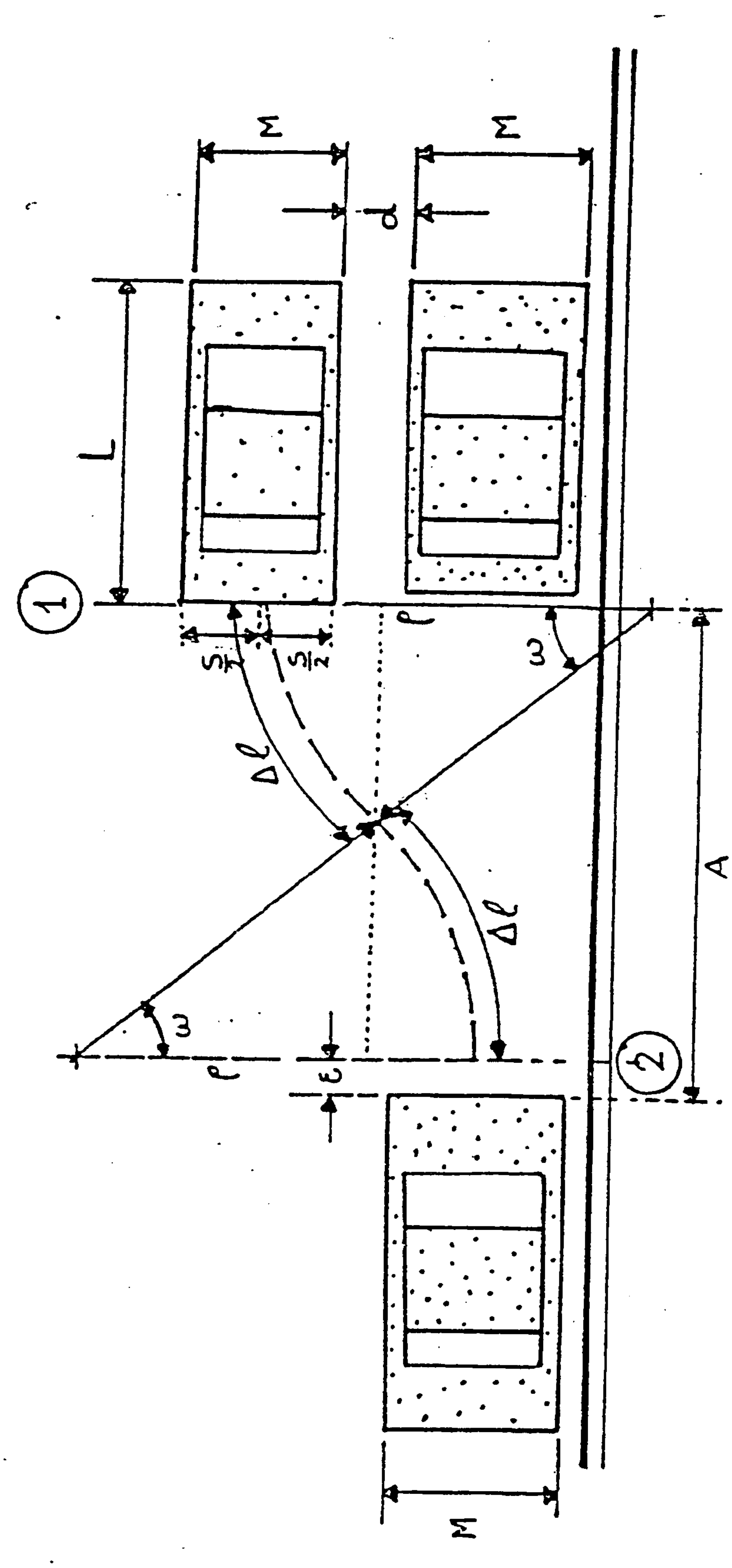


FIGURE 125

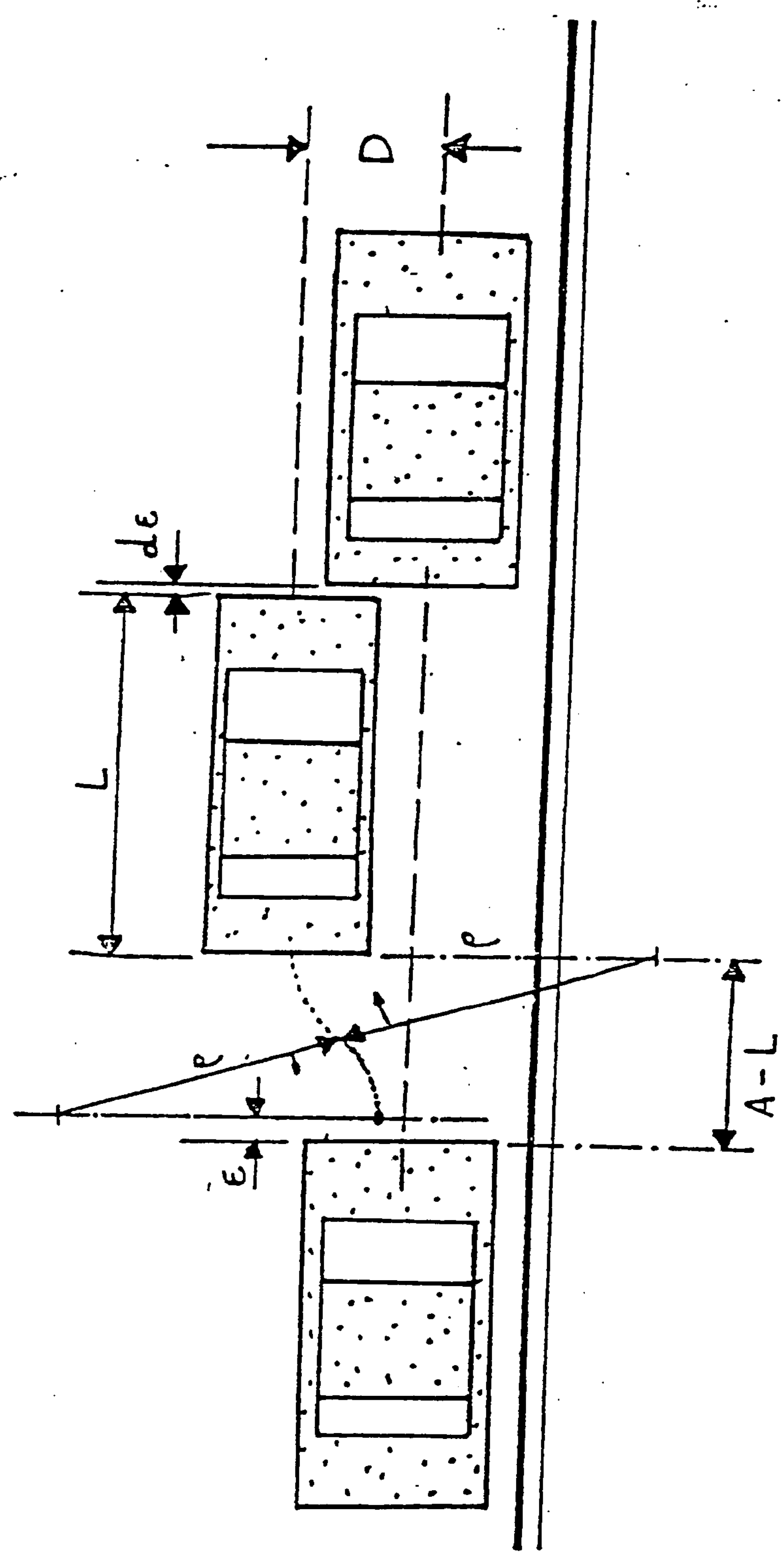
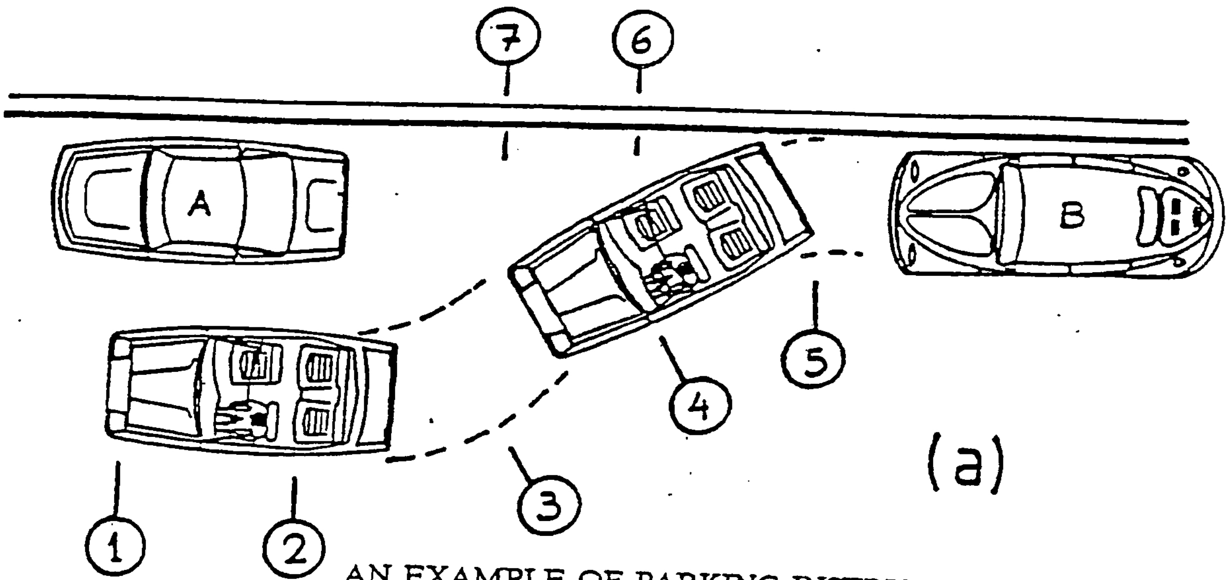


FIGURE 126

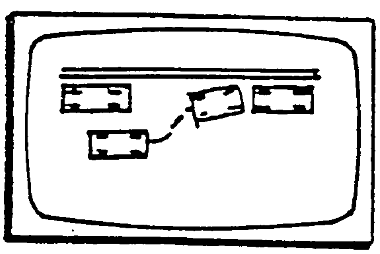


(a)

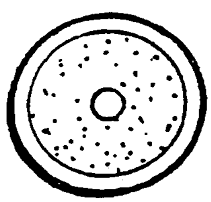
AN EXAMPLE OF PARKING INSTRUCTIONS

VISUALLY

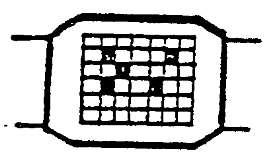
VOCALLY BY TOUCHING



(b)



(c)



(d)

FIGURE 127

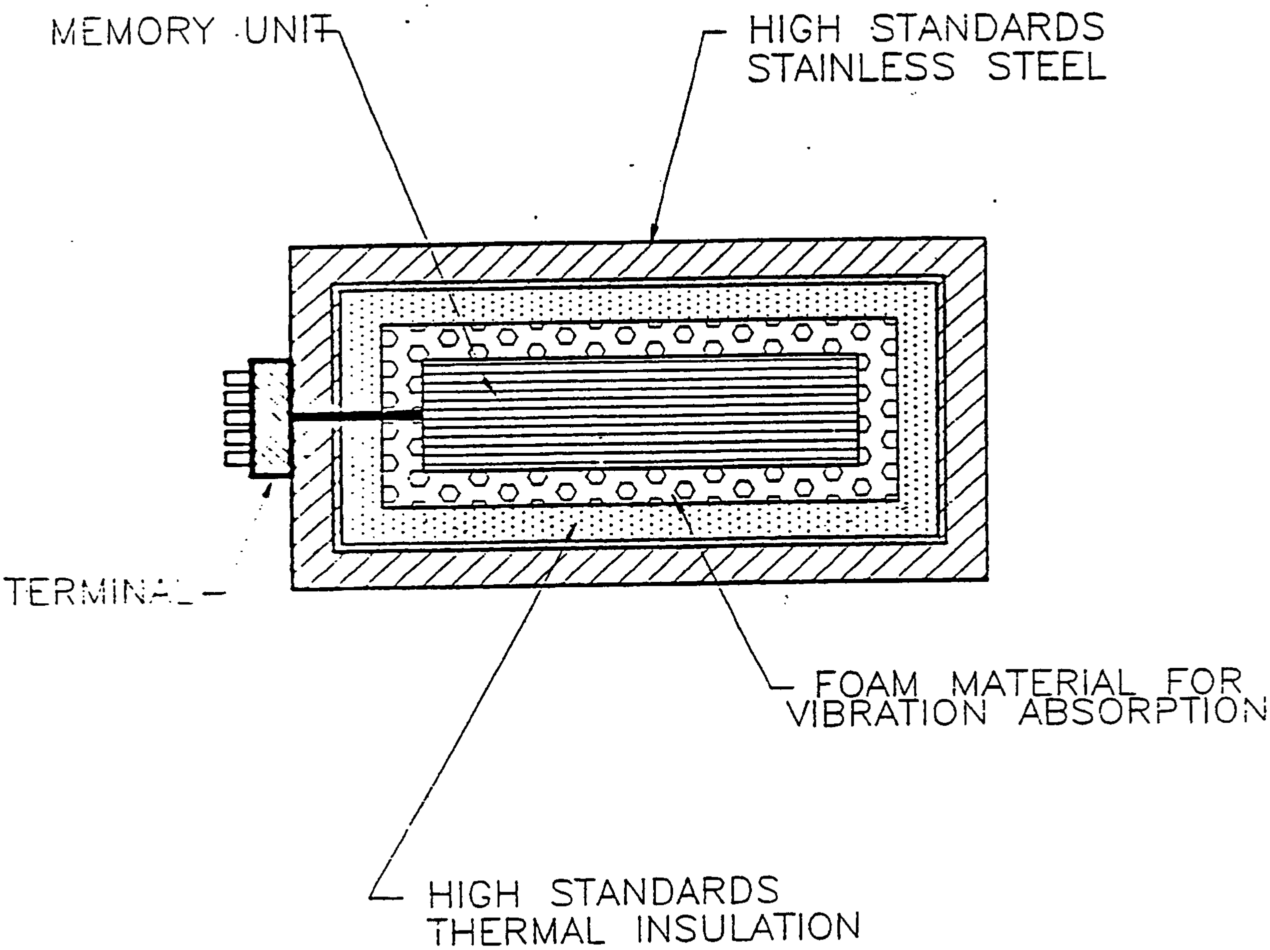

MEMORY UNIT
HIGH STANDARDS STAINLESS STEEL
TERMINAL
FOAM MATERIAL FOR VIBRATION ABSORPTION
HIGH STANDARDS THERMAL INSULATION

FIGURE 128

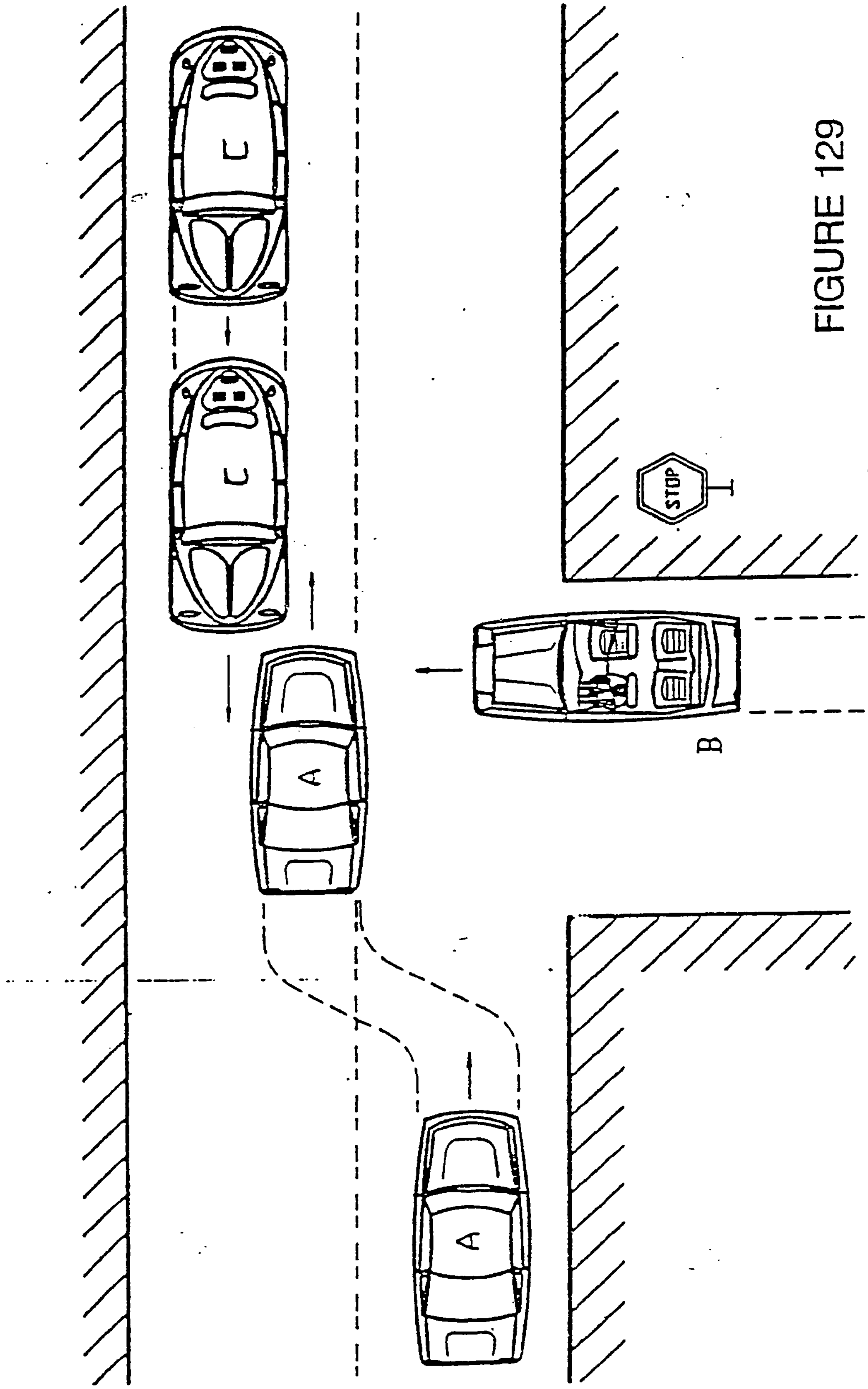


FIGURE 129

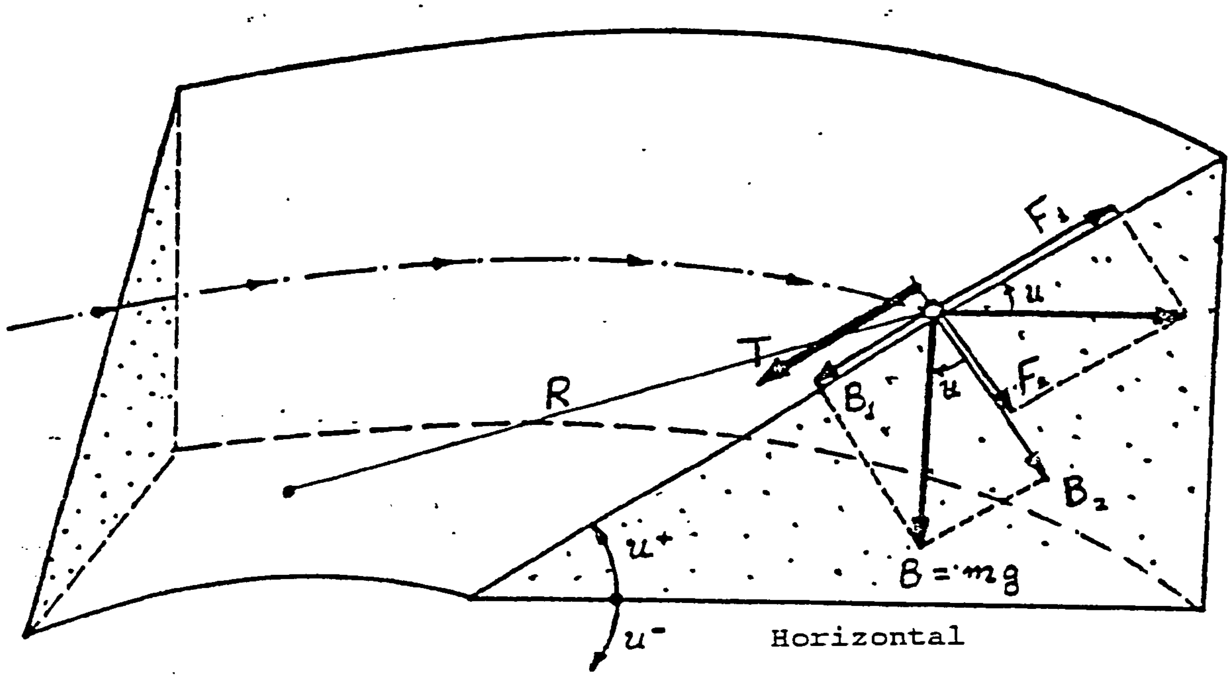


FIGURE 130

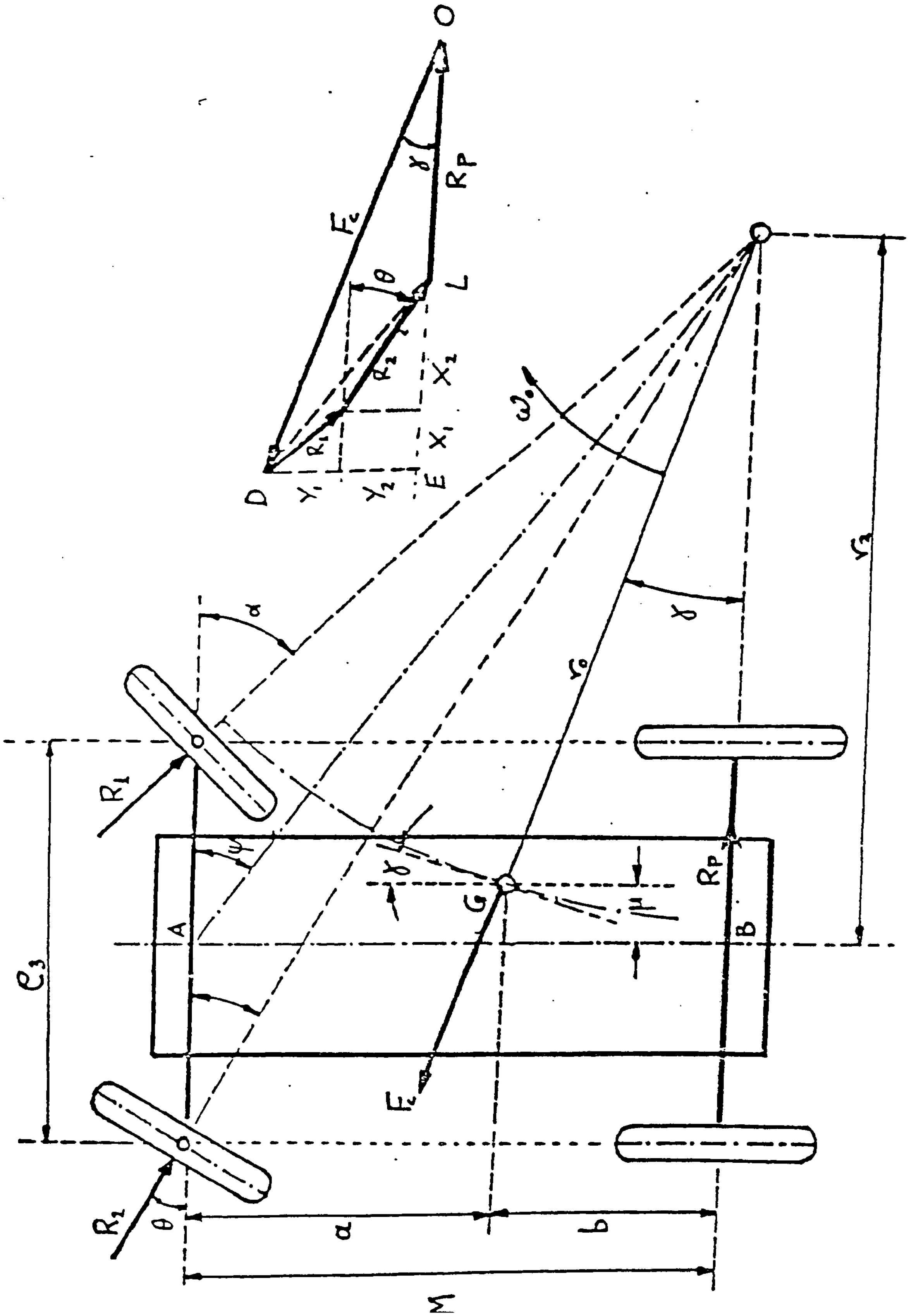


FIGURE 131

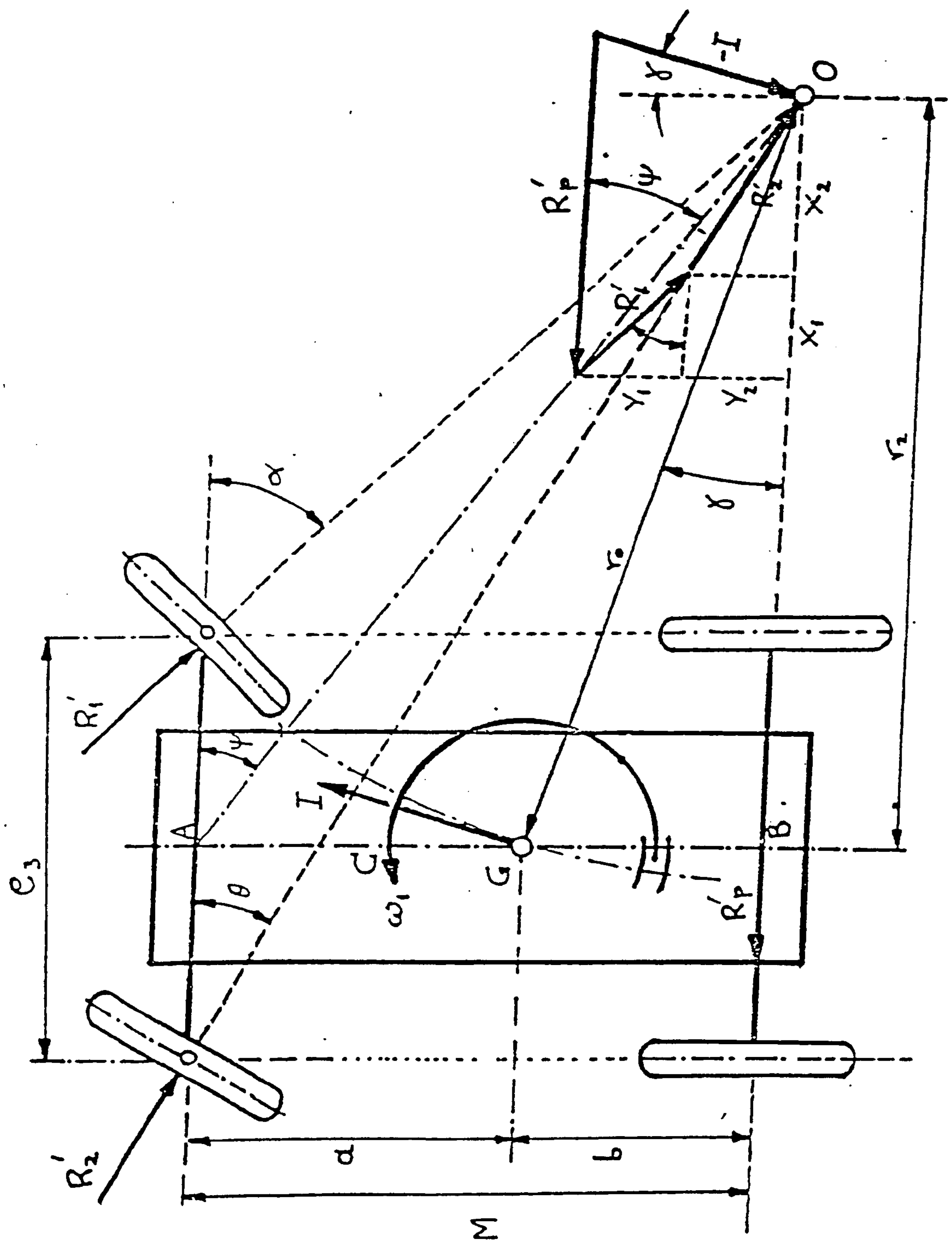


FIGURE 132

INTERNATIONAL SEARCH REPORT

International Application No PCT/GR 92/00016

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 5 G08G1/0968

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 5	G08G

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category°	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
Y	EP,A,0 349 470 (ANAGNOSTOPOULOS) 3 January 1990	1
A	see column 1 - column 4 see column 7, line 60 - column 8, line 45	2-108
Y	EP,A,0 392 953 (TRESSE) 17 October 1990	1
A	see column 3, line 45 - column 4, line 36	69-105
Y	VNIS '89 VEHICLE NAVIGATION & INFORMATION SYSTEMS 11 September 1989, TORONTO CA pages 237- - 243 GILLAN 'PROMETHEUS and DRIVE: Their Implications for Traffic Managers'	1
A	see paragraph 2.3; figure 1	69-108

-/--

° Special categories of cited documents :[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

1

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
15 DECEMBER 1992	22.12.92
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	DHEERE R.F.B.M.

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY vol. 40, no. 1, February 1991, NEW YORK US pages 141 - 146 KAWASHIMA 'Two Major Programs and Demonstrations in Japan'	1
A	see page 142, column 2 - page 143, column 2	2-19, 69-108
A	VNIS'89 VEHICLE NAVIGATION & INFORMATION SYSTEMS 13 September 1989, TORONTO CA pages 165 - 169 GUZOLEK 'Real-Time Route Planning in Road Networks' see page 165, column 2 - page 166, column 2	2-19
A	VEHICLE ELECTRONICS IN THE 90'S:PROCEEDINGS OF THE INTERNATIONAL CONGRESS ON TRANSPORTATION ELECTRONICS P-233 1990, pages 209 - 215 SUCHOWERSKYJ 'Vehicle Navigation and Information Systems in Europe- An Overview' see page 211, column 1 - page 212, column 2	42-68
A	EP,A,0 158 214 (HITACHI) 16 October 1985 ABSTRACT see figure 1	42-68

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GR 9200016 SA 64200

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 15/12/92

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-0349470	03-01-90	None		
EP-A-0392953	17-10-90	FR-A-	2645994	19-10-90
		FR-A-	2652931	12-04-91
EP-A-0158214	16-10-85	JP-A-	60202307	12-10-85
		US-A-	4679147	07-07-87

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82